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ABSTRACTS
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37th ANNUAL MEETING

OF THE

AMERICAN CERAMIC SOCIETY

HOTEL STATLER, BUFFALO, N. Y.

WEEK OF FEBRUARY 17, 1935

AND ANNUAL MEETING OF THE

NATIONAL BRICK MANUFACTURERS RESEARCH FOUNDATION

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A STUDY OF THE EFFECT OF NATURAL GAS AND OF HYDROGEN UPON VARIOUS REFRACTORIES*

By Bertram C. Ruprecht, R. H. H. Pierce, and Fred A. Harvey

ABSTRACT

Natural gas was passed through an electric-tube furnace where it was partially cracked and then through a second furnace containing the sample of a refractory. The refractories tested were fireclay brick of various types and fired in various manners and brick made of magnesite, high alumina material, and silica. The action on the refractory was similar to that of carbon monoxide. Carbon was deposited in some of the refractory bodies within a critical temperature range. Some of the fireclay bodies were almost completely disintegrated by the growth of the carbon deposits, although others were scarcely affected. Hydrogen gas had no disintegrating action at any temperature studied.

I. Introduction

The object of the present investigation was the study of the effect of natural gas and of hydrogen on various refractories at moderate temperatures.

The effect of carbon monoxide on certain kinds of fireclay brick is fairly well known. There is a critical temperature range at approximately 420 to 470°C (788 to 878°F)[1] in which the iron oxide in the fire brick acts as a catalyst in decomposing carbon monoxide. Carbon is deposited within the body of the brick about the various iron-oxide centers and tends to disrupt the brick. Brick which have been removed from certain oil-cracking stills and normalizing furnaces have shown evidence of disruption similar to that caused by carbon monoxide. It seemed reasonable to suppose that there might be some critical temperature for refractories in contact with natural gas, and its determination was attempted. Preliminary tests showed that some fire brick could be disintegrated by natural gas and that it was a two-stage effect: first, the natural gas was cracked and second, carbon was deposited in the brick.

II. Literature

(1) Refractories The effect of carbon monoxide on refractories has been the subject of numerous studies during the last ten years. Perhaps the most recent publication is that by Hugill, Ellerton, and Green.[1] There has been comparatively little study of the effects of gases other than carbon monoxide. Phelps[2] studied the effects of chlorine, sulfur dioxide, and carbon monoxide on refractories of fire clay, silica, diaspore, chrome, and magnesia. The refractories were subjected to the action of the gas for 72 hours at a temperature of 950°C (1742°F), and, in general, showed a considerable loss in strength. Westman[3] studied the effect of carbureted water gas on three types of fireclay brick at temperatures of 550°C (1022°F) and 1100°C (2012°F). He reports that two brands of brick subjected to the gas at 550°C showed a significant decrease in strength, while the third did not. The loss of strength was apparently due to the accumulation of carbon in the brick in a manner typical of carbon-monoxide disintegration. The brick subjected to the gas at 1100°C showed no appreciable loss of strength. Badger[4] studied the effect of oxygen, nitrogen, carbon dioxide, hydrogen, and water vapor on ceramic bodies heated to a temperature of about 1200°C (2192°F). He concluded that water vapor accelerates the rate of vitrification of ceramic bodies containing notable amounts of feldspar, whereas the other gases have little or no effect.

(2) Gases According to Storch,[5] natural gas can be decomposed by heating to a suitable temperature in the absence of oxygen, according to the following reactions:

(1) $CH_4 = C + 2H_2$
(2) $CH_4 = H_2 +$ hydrocarbons containing 2 or more carbon atoms

Important factors controlling these reactions are temperature and the time of contact of the gas in the heated zone of the furnace. Low temperatures and a slow passage of gas through the furnace favor the first reaction, while high temperatures and a more rapid passage of gas are most suitable for the second reaction. The formation of carbon resulting from the first reaction may be prevented by using temperatures above

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February 14, 1934 (Refractories Division). Received February 14, 1934.

[1] W. Hugill, H. Ellerton, and A. T. Green, *Trans. Ceram. Soc.* [Eng.], **32**, 537–50 (1933).

[2] S. M. Phelps, *Amer. Refrac. Inst. Tech. Bull.*, No. 9 (1927).

[3] A. E. R. Westman, *Jour. Amer. Ceram. Soc.*, **11** [8], 633–38 (1928).

[4] A. E. Badger, *ibid.*, **16** [2], 107–17 (1933).

[5] Storch, *Bur. Mines Information Circ.*, No. 6549 (1932).

1500°C and a very short time of contact, 0.1 second or less.

The second reaction is discussed by Egloff.[6] The decomposition products that may be produced consist of numerous and complex compounds and include the following: ethylene, acetylene, toluene, xylene, benzene, naphthalene, anthracene, butylene, and hydrogen. In cracking 90 liters of natural gas, Fisher[7] obtained 5.7 grams of light oil, 1.1 grams of tar, and 3.5 liters of unsaturated gases. He found that approximately one-half of the light oil was benzol and that the tar contained naphthalene, anthracene, and other cyclic hydrocarbons. Other investigators[8] obtained 0.2 gallon benzene, ethylene, and acetylene, equivalent to 8.8% of the original gas, on passing 1000 cubic feet of methane through a tube heated to 1150°C and with 0.6 second contact.

Considerable work has been done by various investigators[9] on determining the effect of catalysts on the thermal decomposition of methane and ethane. Various materials, such as copper, nickel, iron, cobalt, silicon carbide, graphite, charcoal, and activated vegetable and birch charcoal were used. Each of these substances was found to catalyze the reaction $CH_4 = C + 2H_2$. Silica, tungsten, molybdenum, and tin were also used, but did not appear to exert any catalytic effect on this reaction. As yet, no material has been found that will catalyze the second reaction:

CH_4 = H_2 + hydrocarbons of 2 or more carbon atoms.

Silica, magnesia, alumina, and baryta were found to have a retarding effect on this reaction.[10]

Methane is considered to be the most stable member of the hydrocarbon series, consequently the most difficult to decompose by heat. It does not break up to any appreciable extent below 1292°F without the use of a catalyst. On using a nickel or iron catalyst, the thermal decomposition temperature can be reduced to approximately 608°F and 662°F, respectively. However, for the production of the hydrocarbons, it is necessary to use considerably higher temperatures (1832 to 2160°F). Experiments made by heating methane in sealed glass tubes showed that no decomposition occurred when heated at 896°F for six days, and only a slight decomposition, corresponding to 9.07% of the gas, was obtained on heating methane for one hour at 1445°F.

Ethane, the second major constituent of natural gas, undergoes a thermal decomposition at temperatures below 1832°F (see footnote 5). Consequently, it is believed that on subjecting natural gas to temperatures below 1800°F, only the ethane is decomposed to any appreciable extent. The gaseous products formed at this temperature consist largely of ethylene, acetylene, and hydrogen.

III. Procedure

A diagram of the apparatus used in the study with natural gas is shown in Fig. 1. Two electric furnaces were used in most of the tests, so that the cracking temperature and the temperature

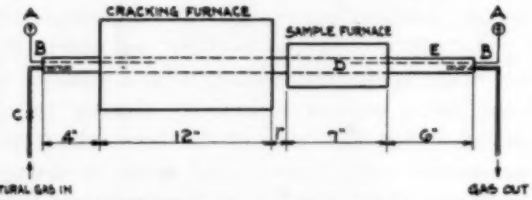

FIG. 1.—*A*, millivoltmeter graduated in °F; *B*, platinum platinum-rhodium thermocouple with quartz protection tube; *C*, valve to control rate of flow of natural gas; *D*, brick sample to be tested; *E*, quartz-tube, diameter 1 inch, length 30 inches.

of the sample could be controlled independently of each other. The temperature of each furnace was regulated with a rheostat and in most cases could be maintained within ± 10°F of that desired. The furnaces were capable of maintaining a temperature of about 1000°C (1832°F). Platinum platinum-rhodium thermocouples, protected with fused quartz tubes and connected to direct-reading millivoltmeters, were used to measure the temperature.

The natural gas was passed through the apparatus at a rate varying from 200 to 850 cubic centimeters per minute. The rate was, of course, constant for any particular test.

The natural gas on passing through the cracking furnace was partially decomposed or cracked. The resulting mixture of raw natural gas and products of decomposition was then passed over

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[6] Egloff, Schaad, and Lowry, *Jour. Phys. Chem.*, **34**, 1617 (1930).
[7] Fisher, *Nat. Petroleum News*, Jan. 9, 1929.
[8] Frolich-White-Dayton, *Ind. Eng. Chem.*, **22**, 20 (1930).
[9] (*a*) Hurd, Pyrolysis of Carbon Compounds.
(*b*) N. A. Klyukvin and S. S. Klyukvina, *Jour. Chem. Ind.* [Moscow], **7**, 743–52 (1930).
[10] Stanley and Nash, *Jour. Soc. Chem. Ind.*, Jan. 11, 1929.

the sample. The two furnaces were close together to prevent, as much as possible, the condensation of certain constituents formed during the cracking process.

In determining the critical temperature range for disintegration, the temperature of the cracking furnace was kept constant while that of the sample was changed for each run until the range was established.

The Equitable Gas Company kindly furnished

TABLE I

TESTS WITH NATURAL GAS

All Tests Using Brick No. 1 Pennsylvania Fire Clay

Fired at cones 8 to 10

Temperature of cracking furnace (°F)	Temperature of sample (°F)	Duration of run	Gas rate (cc./min.)	Appearance of sample		
				Color	Carbon spots	Grading
750	750	6.5 hr.	140	Original	None	100
850	850	24 "	114	Gray	"	90
900	900	24 "	800	"	"	90
1000	1000	2 "	250	Buff (slightly gray)	"	90
1190	1190	48 "	1470	Gray	Few	30
1235	1235	1.75 "	1300	"	"	75
1235	1235	3.75 "	1300	"	"	75
1235	1235	24 "	1300	"	"	45
1365	1365	1 "	1300	"	"	30
1390	1250	1 "	630	Light gray	"	15
1390	1300	1 "	630	" "	"	15
1390	1390	1 "	630	" "	"	15
1395	995	1 "	280	" "	Many	10
1395	1100	20 min.	280	" "	"	15
1395	1100	1 hr.	280	" "	"	10
1395	1205	1 "	280	" "	"	10
1395	1300	1 "	280	Gray	"	10
1460	1160	1 "	425	Light gray	Few	75
1460	1180	1 "	425	" "	Several	90
1460	1210	1 "	550	" "	Few	60
1460	1240	1 "	550	" "	Many	10
1460	1255	1 "	550	" "	"	10
1460	1275	1 "	550	Gray	"	10
1460	1300	1 "	550	Dark gray	Few	75
1480	1480	1 "	750	Light gray	"	75
1600	1050	1 "	440	Gray	Many	10
1620	1040	1 "	550	Light gray	"	15
1630	1050	1 "	550	Gray	Few	30
1630	754	1 "	4800	Tan	None	90
1630	874	10 min.	500	Original	"	90
1630	874	30 "	500	"	"	90
1630	874	1 hr.	500	Gray	Starting to form	90
1630	950	1 "	500	Light gray	Many	10
1630	1000	1 "	270	" "	"	10
1630	1045	1 "	270	" "	"	10
1630	1245	1 "	270	Dark gray	Few	15
1630	1350	1 "	270	Dark gray-purple	"	60
1630	1450	1 "	270	" "	"	75
1630	1630	3 min.	820	Gray	"	75
1630	1630	1 hr.	820	Black	"	60
1700	1020	1 "	550	Light gray	Many	15
1700	1150	1 "	550	Gray	"	15
1700	1200	1 "	270	"	"	15
1700	1300	1 "	270	Dark gray	"	15
1700	1500	1 "	270	Gray	"	15
1700	1600	1 "	270	Dark gray	Very few	45
1700	1670	1 "	270	Black	" "	60
1800	550	1 "	220	Tan	None	90
1800	700	1 "	220	Gray	"	90
1800	900	30 min.	225	"	Very few	75
1800	1000	5 "	425	Buff	None	90
1800	1000	10 "	425	"	Starting to form	75
1800	1000	15 "	425	Buff-gray	" " "	75
1800	1000	30 "	425	Light gray	Many	15
1800	1000	45 "	425	Gray	"	15
1800	1000	1 hr.	425	"	"	0

the following data which were calculated from the B.t.u. value of the gas:

Date	Methane CH_4 (%)	Ethane C_2H_6 (%)
July 9, 1932	80.5	18.5
July 13, 1932	79.0	20.0
Aug. 4, 1932	80.5	18.5
	81.9	17.1
Jan. 18, 1933	83.6	15.4
Jan. 27, 1933	84.4	14.6
Jan. 30, 1933	84.4	14.6

These calculations were based on the assumption that the combined percentage of methane and ethane would represent 99% of the gas.

Although this is not always strictly true, the calculations are probably accurate within 1% or less. Partial gas analyses showed no CO_2, CO, O_2, or unsaturated hydrocarbons present.

The test pieces, $\frac{1}{2}$ by $\frac{1}{2}$ by $2\frac{1}{2}$ inches, were cut from 9-inch straight stock brick. In all cases, a new sample was used for each test in which the temperature conditions were changed.

The following brick were tested:

With Natural Gas

1. Pennsylvania fireclay brick made of flint and semi-flint fire clays, fired to cones 8 to 10.
2. Same, fired to cone 11.
3. Same, fired to cone 12.
4. Same, fired to cone 14.
5. Same, fired to cone 18.
6. Pennsylvania blast-furnace fireclay brick made of flint and plastic fire clay, fired to cone 14.
7. Missouri fireclay brick made of flint and plastic clay, fired to cones 13 to 14.
8. Kentucky fireclay brick made of flint and plastic clay, fired to cone 13.
9. Alabama kaolin brick made of kaolin, fired to cone 18.
10. Pennsylvania silica brick made of Pennsylvania ganister with lime bond, fired to cone 17.
11. Pennsylvania silica brick made of Pennsylvania ganister with lime bond, fired to cone 14.
12. Missouri diaspore brick, 70% Al_2O_3, made of Missouri diasporitic clay, fired to cone 18.

TABLE II

TESTS WITH NATURAL GAS

Using Brick Numbers 2 to 14, Inclusive

Brick No.	Temperature of cracking furnace (°F)	Temperature of sample (°F)	Duration of run (hr.)	Gas rate (cc./min.)	Appearance of sample: Color	Appearance of sample: Carbon spots	Appearance of sample: Grading
2	1630	1000	5	400	Gray	Few	75
2	1630	1000	22	400	Black	"	30
3	1630	1000	$2\frac{1}{2}$	400	Gray	Many	10
3	1630	1000	19	400	Black	"	0
4	1630	1000	209	420	"	None	90
5	1600	975	6	440	Dark brown	"	90
5	1600	1100	48	440	Black	"	90
5	1620	1020	17	600	"	"	90
5	1600	1050	180 } 280	700	"	"	90
5	1700	1100	100 }	400	"	"	90
6	1630	1000	206	400	Dark gray	"	90
7	1630	1000	234	400	Gray	Few	45
7	1700	1000	67	400	"	"	30
8	1630	1000	203	400	Dark gray	Several	30
9	1600	1050	2	700	Brownish gray	None	90
10	1600	1100	48	440	Gray-black	"	90
11	1600	1050	210	700	Black, coated with carbon	"	90
12	1460	1180	1	450	Brownish gray	"	90
12	1600	1000	50	450	Dark gray	"	90
12	1800	1000	3	425	Black	"	90
12	1800	1000	50	410	"	"	90
12	1800	1300	28	550	"	"	90
12	1800	1500	50	460	"	"	90
13	1600	1050	210	700	"	"	90
14	1600	1000	50 } 230	450	"	"	90
14	1600	1050	180 }	700	"	"	90
14	1800	1300	28	550	"	"	90
14	1800	1500	50	460	"	"	90

13. Missouri diaspore brick, 70% Al_2O_3, made of Missouri diasporitic clay, fired to cone 14.
14. Missouri diaspore brick, 50% Al_2O_3, made of Missouri diasporitic clay, fired to cone 14.

With Hydrogen

1. (See above.)
10. (See above.)
12. (See above.)
14. (See above.)
15. Missouri diaspore brick, 60% Al_2O_3, Missouri diasporitic clay, fired to cone 14.
16. Magnesia brick made from Austrian dead-burned magnesite, fired to cone 18.
17. Chrome brick made from Rhodesian chrome ore, fired to cone 16.

In all, about one hundred tests were made,

varying in duration from five minutes to 234 hours.

DATA

Key to Grading Sample

Unaffected	100
Discolored, no carbon spots	90
Sound, small carbon spots	75
Sound, large carbon spots	60
Cracked, carbon spots	45
Broken, carbon spots	30
Partially disintegrated, carbon spots	15
Further disintegrated, carbon spots	10
Completely disintegrated, carbon spots	0

The following table shows the effect of the rate of flow of natural gas into the apparatus upon the percentage of unsaturated hydrocarbons present in the exit gases. The cracking temperature was held constant at 1600°F.

TABLE III

Gas flow (cc./min.)	Unsaturated hydrocarbons (%)
80	6.1
345	9.2
640	10.0
810	10.5

The relation between the cracking temperature and the percentage of unsaturated hydrocarbons present in the exhaust gases was determined for many of the temperatures used in this study. The following data were obtained on passing natural gas through the apparatus at a constant rate of flow, 375 cubic centimeters per minute, for each of the temperatures shown below:

TABLE IV

Cracking temperature (°F)	Gaseous unsaturated hydrocarbons found (%)
1250	2.3
1350	6.3
1450	9.8
1500	10.2
1550	10.1
1600	9.3
1650	8.6
1700	7.6
1750	5.4
1800	5.2

Although the percentage of gaseous, unsaturated hydrocarbons decreased as the cracking temperature was increased above 1550°F, the percentage of natural gas decomposed above this temperature actually increased due to the larger amounts of liquid hydrocarbons formed at the high temperatures.

IV. Notes and Discussion

(1) Effect of Natural Gas The initial tests were run using a single furnace. Pennsylvania fireclay power-pressed brick fired to cones 8 to 10, heated at 750°F for 6½ hours were not affected by natural gas and were only slightly discolored when heated for 24 hours at 850°F and at 900°F. The discoloration was probably due to an extremely thin film of carbon depositing on the outer surface of the sample. Disintegration and formation of carbon spots occurred first at 1190°F during a run of 38 hours. The carbon deposits formed around the iron spots and the size of the original iron spots seemed to determine to some extent the amount

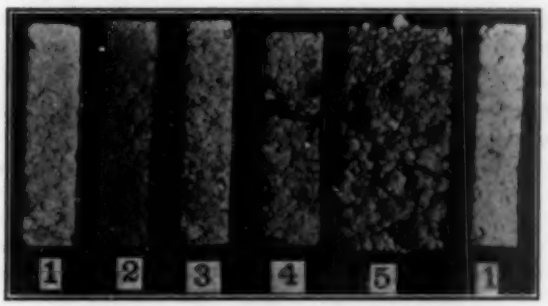

FIG. 2.—Effect of natural gas: (1) untested specimens (for comparison); (2) specimen discolored only; (3) specimen showing carbon spots; (4) specimen fractured; and (5) specimen broken into fragments.

TABLE V

TESTS WITH HYDROGEN GAS USING BRICK OF VARIOUS TYPES

Brick No.	Temperature (°F)*	Time (hr.)	Appearance	Grading
1	850	3	Discolored, purple-black	90
1	800–900	19	" " "	90
1	1200–1300	48	" " "	90
1	1700–1800	123	" dark gray	90
10	850	3	" gray	90
10	800–900	19	" "	90
10	1200–1300	48	" green-gray	90
10	1700–1800	123	" dark gray	90
14	1600–1800	70	" dark gray-purple	90
15	1600–1800	70	" " " "	90
12	1600–1800	70	" " " "	90
16	1600–1800	90	" black	90
17	1600–1800	90	Slightly red, cracked	45
17	1600–1800	24	Slightly red	90

* In the tests with hydrogen a single furnace was used.

of carbon that would deposit. This condition was found on removing samples containing carbon spots and heated above 1480°F. In the presence of air, the hot carbon burned and left a small, fluffy deposit of iron oxide which was considerably larger in volume than the original spot, indicating that the iron compounds had been reduced and then the iron oxidized to Fe_2O_3.

Following the initial tests, two furnaces were used as shown in Fig. 1. The gas was first passed through a cracking furnace and then through a second furnace in which the brick specimen was placed. Under the conditions most favorable for disintegration, a specimen of the type susceptible to disintegration could be reduced to a powder in about an hour. This effect increased as the temperature of the cracking furnace was raised and might have been even greater at a temperature above 1800°F, the maximum temperature which could be reached. The following table gives the temperature ranges over which disintegration occurred for various temperatures of cracking.

TABLE VI

Temperature of cracking furnace (°F)	Temperature of specimen (°F)
1395 ± 10	995–1300
1460 ± 10	1240–1275
1630 ± 10	950–1000
1700 ± 10	1020–1500
1800 ± 10	900–1000+

While it appears from this table that the temperature range was broader for 1395°F and 1700°F than at the other temperatures, it is not felt that this conclusion was definitely established. All of the tests at these temperatures shown in Table I were for one hour or less. Longer tests might have produced complete disintegration at temperatures outside the ranges shown. There also appeared to be a tendency for the critical temperature to be lower as the cracking temperature was increased, although a statistical analysis of the data would not permit this conclusion to be definitely stated.

To determine whether the disintegration of the brick was accompanied by a formation of either CO or CO_2, analyses of the exhaust gases were made at the end of a 30- and 60-minute period, during which a sample disintegrated completely. The gas analyses indicated that neither CO nor CO_2 was produced in measurable quantity during the period in which the brick disintegrated and that the percentage of unsaturated hydrocarbons in the exit gases decreased approximately 1.0% during the 60-minute run. It would appear, then, that the disintegration of the brick was caused by a deposition of carbon due to the decomposition of the unsaturated hydrocarbons. The iron compounds in the brick seemed to be the foci of this reaction.

A sample of Pennsylvania brick (fired to cones 8 to 10), tested for one hour at 1045°F (cracking temperature, 1630°F) was examined under a microscope to determine, if possible, the exact manner in which the carbon deposition occurred. The test piece selected was gray in color and had disintegrated almost completely. It was observed that the deposition of the carbon occurred only as spots and that none was present as a film around the clay grains. Since the individual grains of flint clay appeared as a white material, it was assumed that the carbon had not penetrated them. Observations made on samples of Pennsylvania brick, fired to cone 18, indicated that very little, if any, penetration of carbon into the clay grains had occurred during a one-hour period. Longer periods of exposure, however, showed penetration.

Samples of Pennsylvania brick, fired to cone 18, tested for 6, 100, and 280 hours were broken and the interior fractured surface was examined microscopically. A large amount of carbon had deposited as a film within each of the test pieces. A large proportion of the specimen was composed of grains with an opaque, glassy luster which were not covered with the carbon film that enveloped the rest of the specimen. It is believed that these grains represented the flint clay in the brick mix. In addition to the deposition of carbon over the surfaces of the grains of semi-flint clay, the carbon penetrated the flint clay. An examination of the sample tested for six hours showed that the carbon had penetrated the larger grains of flint clay to only a slight extent, although smaller grains showed complete penetration. Complete penetration of carbon into all grains of flint clay was observed in samples tested for 100 hours and 280 hours.

A sample of brick, 100% kaolin, fired to cone 18, tested for two hours at 1050°F (cracking temperature 1600°F) became discolored. The test piece showed no evidence of disintegration. A microscopic examination of the interior surface

of the sample showed that the individual grains were partly discolored, due to a penetration of carbon. The discoloration occurred mostly at the outer edge of the grains.

A sample of Pennsylvania brick, fired to cones 8 to 10 and heated to 1800°F for 123 hours in a hydrogen atmosphere, was tested with natural gas at 1050°F for one hour. The outer surface of the test piece was coated with carbon, and only a few small carbon spots formed with no evidence of disintegration. The inner portion of the sample was a dark gray. Samples, not subjected to the hydrogen treatment, were tested under the same conditions and disintegrated almost completely. These samples contained many carbon spots and were always a much lighter gray in color.

A sample of Pennsylvania brick, fired to cone 18, and held within the critical temperature range (1020 to 1500°F) for natural gas cracked at 1700°F, showed no disintegration during a period of 100 hours. A coating of carbon formed on the outer surface during the first 23 hours and increased slightly during the remainder of the run. On breaking the sample at the end of the test, it was found that some carbon had deposited as a thin film throughout the test piece and appeared to cover only certain constituents in the brick mix. The manner in which the carbon deposited in these samples differed considerably from that noted in the case of medium to hard "burned" brick. In the latter case, the deposition of the carbon occurred only in the form of small carbon spots, ranging in size from a speck to $^1/_8$-inch diameter, and never as a film. In both cases, the deposition of carbon refers to that taking place within the sample. A sooty deposition of carbon frequently formed on the outer surface of the samples and appeared to have no bearing upon the disintegration of the test piece. The sample of Pennsylvania brick, fired to cone 18, previously tested for 100 hours, was run for an additional 180 hours at 1050°F, a critical temperature for natural gas cracked at 1600°F. It was thought that during a prolonged test the deposit of carbon in the pores of the brick would gradually increase and ultimately disrupt the brick. However, the appearance of the sample was the same after the 280-hour test as after that run for 100 hours.

The data show that fireclay brick, fired to cone 14, are more resistant to disintegration than lighter fired brick. It was thought that a microscopic examination of the two brick of different firings might show a cause of the greater resistance of the higher fired brick. Accordingly, samples were submitted to C. R. Fettke of the Carnegie Institute of Technology. While the evidence is not entirely positive, it would appear that the iron was in different states in the two brick, probably more of the iron as oxide in the brick of lower firing, and dissolved in the glass or as crystalline silicates in the brick of higher firing. Dr. Fettke's report follows:

Report on the Microscopic Examination of Samples of Pennsylvania Fire Brick

Thin sections of the two samples were prepared in such a way as to show the "iron spots."

Pennsylvania Brick, Fired to Cone 11 (Lab. No. A6499R) The areas discolored by iron represent small portions of the brick that have undergone incipient fusion. These patches are quite porous, possessing a blebby appearance in thin sections. To a large extent, they consist of glass in which are imbedded minute mullite crystals, still too small to measure readily. This matrix of glass and mullite is full of minute dendrites of a dark reddish-brown, almost opaque substance believed to represent largely ferric oxide. Part of it is attracted by the ordinary magnet so that some magnetite is probably also present. Some of the round pores are encircled by a ragged ring of this material in such a way that any gases entering the pores would come in intimate contact with it. In addition to the above nearly opaque dendrites, some iron is also present in much elongated feather-like growths of a brownish color in the glass and mullite matrix. Their cross-sectional area is very small. It was not possible to determine the form in which the iron is present in these growths.

Pennsylvania Brick, Fired to Cone 14 (Lab. No. A6500R) The discoloration due to the presence of the iron has spread so that it occupies a larger volume. As in A6499R (cone 11 brick) the discolored areas have undergone incipient fusion and have the same porous, blebby. appearance. The mullite crystals have grown considerably in size, some of them reaching lengths of 0.125 millimeter and widths of 0.007 millimeter. Much of the glass between the mullite crystals has taken on a pale yellowish-brown color indicating that more iron has gone into solution in it than in A6499R. The almost opaque dendrites of A6499R have, to a large extent, disappeared. There are present, however, a considerable quantity of elongated, somewhat irregular-shaped bodies of a very dark brown color, the larger ones being nearly opaque, that undoubtedly represent some iron compound. It was impossible to establish definitely whether the iron in these is present as a silicate or whether it is still in the oxide form. In size, they are of about the same dimensions as the larger mullite crystals. When powdered material containing them is treated with hydrofluoric acid, they disappear, which is not the case

with the dendrites of A6499R, some of which were still readily recognizable in the residue remaining after treatment with hydrofluoric acid. The dark brown compound is uniformly distributed throughout the mullite and glass matrix and completely enclosed in it. In no case does it line the pores as do some of the dendrites of A6499R, so that even if it does represent uncombined iron oxides, gases entering the pores would not have the opportunity to come in direct contact with it.

A sample of silica brick (No. 10), fired to cone 17, was tested for a 48-hour period (cracking furnace 1600°F, specimen 1100°F). It was badly discolored and had a metallic gray luster. To determine the effect of firing on its tendency to disintegrate, a silica brick fired to cone 14 (No. 11) was selected and tested for 210 hours. During this test, the sample acquired the same metallic gray color as the one previously described. Neither sample showed any evidence of disintegration.

On heating the second sample to a red heat in an oxidizing atmosphere for several hours, the gray color disappeared and the test piece again had its original appearance. The discoloration noted in both samples was probably due entirely to carbon, although such a deposition was visible only with the use of a microscope.

A microscopic examination of the tested samples of silica brick, fired to cone 14 and to cone 17, showed that the carbon had penetrated them to a considerable extent and had discolored the test pieces.

A diaspore brick (70% Al_2O_3), fired to cone 18, was tested at various temperatures, as shown in Table III, for as long as 50 hours. All of the samples were badly discolored, indicating the presence of small amounts of carbon. However, there was no evidence of disintegration. The same mix, fired to cone 14, was then tested to determine the effect of degree of firing on the resistance of this brand to disintegration by natural gas. The sample was tested for 210 hours at 1050°F (cracking temperature 1600°F), one of the temperatures used in testing the samples fired to cone 18. The sample was badly discolored and had the same appearance as those fired to cone 18 tested for 50 hours.

A diaspore brick (50% Al_2O_3), fired to cone 14, was tested at different temperatures for periods of 28, 50, and 230 hours. The samples were very much discolored due to carbon which, as shown by the microscope, had deposited in about the same manner as in the samples of 70% alumina brick.

The number of tests on Missouri and Kentucky fireclay brick was so small that it is not believed the relative resistance to disintegration was established.

Most of the specimens were quite completely covered with a coating of soot during the various tests. In order to determine whether or not the soot acted as a protective coating, a specimen of Missouri fireclay brick (No. 7) was subjected alternately to the effect of natural gas, then to a stream of oxygen. The specimen showed more disintegration than when subjected only to the stream of natural gas. This may be due either to the elimination of the sooty coating or to a change in the structure of the iron spots. After the first oxidation period, the iron spots occupied a larger volume than originally and were more porous. In the succeeding reduction period, a larger amount of carbon deposited about these porous iron spots than before, consequently tending to exert a greater disruptive force on the brick. Such a growth in the carbon spots was observed only in the second cycle.

A "hard-burned," Pennsylvania blast-furnace brick (No. 6) of the type which resists carbon monoxide disintegration was tested for 206 hours at 1000°F (cracking temperature 1630°F). An examination of the sample at the end of the test showed that carbon had deposited as a film throughout the sample, but that there were no large carbon spots or evidence of actual disintegration.

V. Discussion

(1) Effect of Hydrogen The physical structure of all the test pieces with the exception of chrome brick was apparently unaffected by hydrogen at all of the temperatures and periods of time used in the tests. The only apparent effect of the hydrogen on these samples was a discoloration which was probably due to a partial reduction of the iron compounds in the brick. The discoloration was intensified as the temperature was increased. The discoloration noted in these brands was as follows:

Pennsylvania fired to cones 8 to 10, light purple and dark gray
Silica, light green and dark gray
Diaspore brick, 50, 60, and 70%, dark gray
Magnesia, metallic gray luster.

Silica brick tested for three hours at 1200 to 1300°F became mottled with green. Large pieces of silica, which originally appeared as white material, were the same color at the end of the test. On continuing this run for 48 hours, the green color changed to gray, indicating, perhaps, a further chemical change.

The sample of chrome brick tested for 90 hours at 1600 to 1800°F was slightly cracked at the end of the first 45 hours. At the end of the 90-hour run, the sample had cracked to such an extent that it could be broken very easily. Although the sample was heated to 1600 to 1800°F at a rapid rate, approximately 500°F an hour, and cooled quickly on being withdrawn from the furnace, a subsequent test indicated that the test piece did not crack due to thermal change.

The color of the sample of chrome brick submitted to the hydrogen treatment for 90 hours was red-brown. On breaking the piece, it was found that, except for portions of the center which were black, the entire sample was red-brown and contained numerous small red spots which were slightly brighter in color than the remainder of the sample. The black portion of the sample, having lost its former luster, differed materially from the original in appearance. The bond of the entire sample was seriously impaired. In addition to these changes, the sample became decidedly magnetic as shown by testing it with a small magnet. Pieces of the original sample were not attracted to the same magnet. The chief magnetic constituents of chrome ores are usually considered to be magnetite (Fe_3O_4) and magnesio-ferrite ($MgO \cdot Fe_2O_3$). The formation of these substances through the reducing action of hydrogen on the iron compounds would be possible.

It is evident that much work remains to be done. Cracking temperatures above 1800°F should be studied. The critical ranges should be thoroughly explored at a number of cracking temperatures. Cold crushing tests should be made on refractory specimens which have been subjected to the action of the gas, but have not cracked or disintegrated. It also appears evident that in all future work an exact knowledge of the firing treatment to which the refractory was subjected is necessary. Many of the data in the literature on carbon monoxide disintegration appear contradictory because of a lack of information on the firing treatment given the refractories studied.

VI. Conclusions

(1) Certain fireclay brick may be completely disintegrated into a powder if subjected to natural gas under certain conditions.

(2) In order to produce the most pronounced effect, the gas should first be "cracked" at a temperature of 1400°F or higher and then passed over the refractory at a temperature between 900°F and 1500°F.

(3) Disintegration by natural gas appears to be much the same phenomenon as disintegration by carbon monoxide, but appears to take place in a different temperature range.

(4) Fireclay brick fired to cones 8 to 10 may be completely disintegrated by natural gas, while if fired to cone 14 or higher they did not disintegrate in 200 hours.

(5) If a refractory is subjected alternately to natural gas and oxygen at temperatures within the critical range, the disintegrating action is accelerated.

(6) Diaspore and silica brick were not disintegrated by natural gas.

(7) Hydrogen gas passed over fireclay brick, silica brick, diaspore brick, and magnesia brick at temperatures ranging from 800 to 1800°F failed in every case to produce any disintegration. Chrome brick cracked and lost strength when subjected to hydrogen at 1600 to 1800°F.

(8) It is not merely a "reducing gas" which disintegrates fireclay refractories. It appears also to be necessary that the gas be in a condition to deposit carbon in the body of the refractory.

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A METHOD OF MEASURING THERMAL CONDUCTIVITY AT FURNACE TEMPERATURES*

By Clarence E. Weinland

ABSTRACT

An apparatus of original design for the measurement of the thermal conductivities of insulating and refractory materials at temperatures up to 2600°F was constructed. The primary heat was supplied by Globar resistors, and the rate of heat flow measured by a calibrated "heatmeter," means for the calibration of which were incorporated in the apparatus itself. The test specimen consisted of eight standard-size brick forming a section 18 by 18 by $2^1/_2$ inches in size.

The results of six complete tests are given: one of a high-temperature insulating brick, one of a fireclay brick, and four tests of refractory insulating brick. In two cases, comparative results from tests in a different type of apparatus are shown. The accuracy of the results obtained in testing insulating and refractory insulating brick is believed to be fully equal to the requirements of engineering use.

I. Introduction

When the problem of setting up a high-temperature thermal conductivity apparatus arose, a thorough investigation of existing test methods led to the conclusion that all were open to question in regard either to applicability or accuracy. It was therefore necessary to evolve a new design, using as many as possible of the worth-while features of previous methods.

The requirements to be met by the test equipment in many respects were severe, though the severity consisted in being able to meet the wide range of imposed conditions with accuracy sufficient for engineering purposes, rather than in giving restricted results of extreme precision.

Note: The samples were to be tested at temperatures up to at least 2500°F on the hot face and up to at least 2000°F mean temperature within the sample, so that data could be obtained throughout the entire range of usefulness of high-temperature insulating materials without the necessity for extrapolation of results.

The materials were also to be tested in their ordinary units of size and shape, rather than in some odd spherical or cylindrical form or in diminutive size. Nearly all high-temperature insulators and refractories are sold as standard-size brick, so it was decided to build up the test specimen from several brick and, further, to include the effect of joints in the overall results.

The materials used in furnace construction vary widely in thermal conductivity. Therefore, it was considered essential that the apparatus be capable of testing (1) insulating materials, (2) refractories, such as fireclay and silica brick, and, if possible, (3) super-refractories.

In addition to the above requirements imposed specifically, there are a number of general requirements which must be met by any similar thermal conductivity apparatus. It is assumed, as a mathematical basis for this type of test, that the two faces of the section of the sample in which the heat flow is measured are plane and parallel, that each is at a uniform, steady temperature throughout, and that the lines of heat flux through the sample are perpendicular to these two faces. The temperatures of the two faces must be known, as well as their area and the distance between them, and the rate of heat flow must be constant and known.

* Presented as part of the Symposium on Heat Transfer through Refractories and Insulation in Industrial Furnaces, at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February 15, 1934. Received March 15, 1934.

II. Design of the Apparatus

Figure 1 shows the exterior of the apparatus. Figure 2 is a photograph of the interior after the insulating powder was removed, showing the Globar chamber, the specimen built up of brick, and the heater assemblies. Figure 3 is a vertical section through the center of the interior set-up, with the elements arranged for low-temperature testing and for calibrating the heatmeter, while Figs. 4*a*, 4*b*, 4*c*, and 4*d* show details of several of the separate elements which make up the assembly of Fig. 3.

(1) Placement of Test Brick

The 18- by 18-inch test specimen (Fig. 4*a*) was assembled from eight standard-size brick, two of which constituted the actual sample the conductivity of which was to be measured. The other six may be of other material, approximately the same in thermal conductivity. The joints between brick may be made with refractory cement if desired. However, in all the work done with this apparatus to date, joints were made by grinding the edges of the brick plane and perpendicular with the faces, and setting them together without cement of any kind. The six guard-section brick were usually set in direct contact with the two center ones, but in special cases it may be advisable to reduce the center brick to $4^1/_4$ by $8^1/_2$ inches in size, leaving a space $^1/_4$ inch wide between center and guard brick to be filled with powdered insulation as a means of reducing the opportunity

for exchange of heat between the center and guard. The two thermocouples used in each face of the test sample were 90 platinum, 10 rhodium, No. 24 B & S. They were cemented into shallow grooves cut into the surface of the brick, and care was taken that the junction of each couple and at least two inches of wire

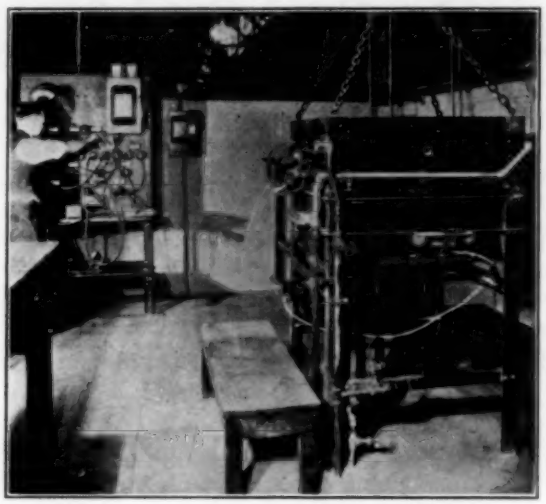

FIG. 1.—An exterior view of the apparatus with its electrical switchboard in the background.

adjacent to it lay as nearly in the plane of the surface as possible.

(2) Test Brick Covered with Carbofrax Plate Immediately above the test specimen was a plate of Carbofrax, $^3/_4$ inch thick and of the same area as the entire sample. Because of the very high thermal conductivity of this material, it served as a temperature equalizer, giving probably as near an approach to an isothermal surface as is practically obtainable. At the same time it served as the floor of the Globar chamber above it. In order to reduce the possibility of local heating of the specimen by uneven contact with the Carbofrax plate, the latter was supported only at the corners by small patches of granular material, giving a separation between plate and specimen of about $^1/_8$ inch over 95% of the area.

(3) Heating Elements Heat was supplied by six Globar elements, each $^7/_8$ inch in diameter and 22 inches long, fitted with water-cooled electrodes. Metal shims made of thin Nichrome sheet were necessary between the ends of the Globars and the terminals. When pitted by arcing they can be readily replaced without requiring resurfacing of the terminal ends.

The Globars were supported by end plates made of Firecrete, which, in combination with the small side tile and the Carbofrax cover plate, formed a demountable radiation chamber, approximately $16^1/_2$ by $16^1/_2$ by 5 inches inside. This radiation space served to distribute the heat from the Globars and acted as an added precaution against localized heating of the specimen.

The exterior of the radiation chamber, with the ends of the Globars protruding, is clearly visible in Fig. 2.

(4) Heatmeter below Test Brick The heatmeter was below the specimen and in contact with it, as shown in detail in Fig. 4*b*. This consists essentially of a slab of ceramic material (Alundum) through which the heat must flow. The temperature drop across this element is a function both of the rate of heat flow and of the element temperature, so a platinum-rhodium differential thermocouple of sixteen junctions was embedded in it for the measurement of the temperature drop, and an ordinary platinum-rhodium single-junction couple was also included to enable measurement of the temperature of the plate itself.

The center section, having the thermocouples embedded in it, was a solid unit $8^1/_2$ by $8^1/_2$ by

FIG. 2.—The interior assembly of the apparatus with the upper portion of the frame and the insulating powder removed.

$^1/_2$ inches in size, and was surrounded by a guard section formed of four plates made of similar material, each $4^1/_2$ by $13^1/_2$ by $^1/_2$ inches in size.

The $^1/_4$-inch gap between center and guard plates was filled with insulating powder.

(5) Calibrating Heater Primarily as a means of calibrating the heatmeter, a group of heaters which could themselves be used as a low-temperature thermal conductivity apparatus were located below it. When making such a calibration, the Globar unit is run at a lower temperature than the calibrating heaters, so that the measured heat generated electrically in the latter flows upward through heatmeter and test specimen in series. The upper one of the latter heating units will be referred to as the "calibrating heater," and is shown in detail in Fig. 4*c*. Its center element consists of an Alundum slab, $8^1/_2$ by $8^1/_2$ by

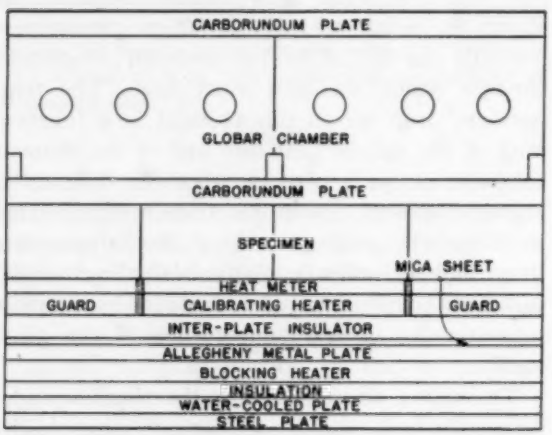

FIG. 3.—Vertical section of the interior apparatus assembly as set up for calibration of the heatmeter.

$^3/_4$ inches in size, having embedded in it a heating element consisting of Nichrome IV wire, B & S No. 19, looped back and forth across the plate with $^1/_4$-inch pitch. Two terminal leads are connected to each end of the winding, one for current and the other for a potential connection to the wattmeter.

The guard section of this heater is made up of four Alundum heater plates, each $4^1/_2$ by $13^1/_2$ by $^3/_4$ inches in size. The windings in the latter are Nichrome IV wire, No. 15 B & S, looped back and forth the short way of the plate on a $^1/_4$-inch pitch. The four guard elements are connected in series-parallel.

Between the center and guard elements there is a $^1/_4$-inch slot, in which is located a calcined Sil-O-Cel insulator $^1/_4$ inch thick by $^3/_4$ inch wide, having embedded in it a platinum-rhodium

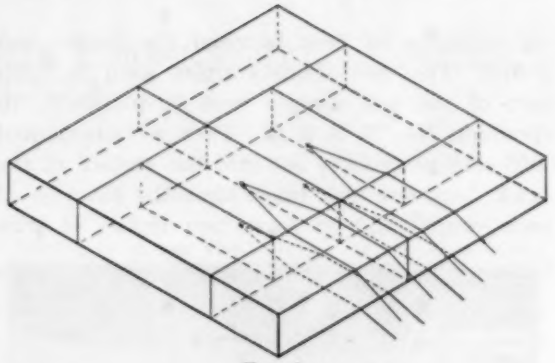

FIG. 4*a*

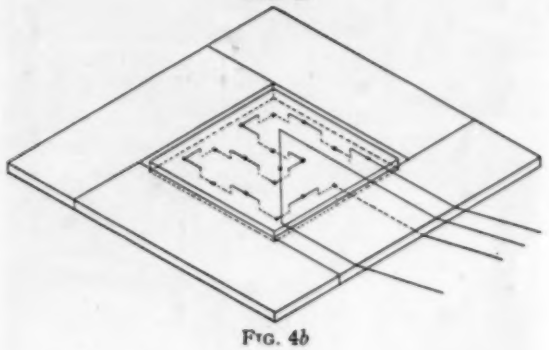

FIG. 4*b*

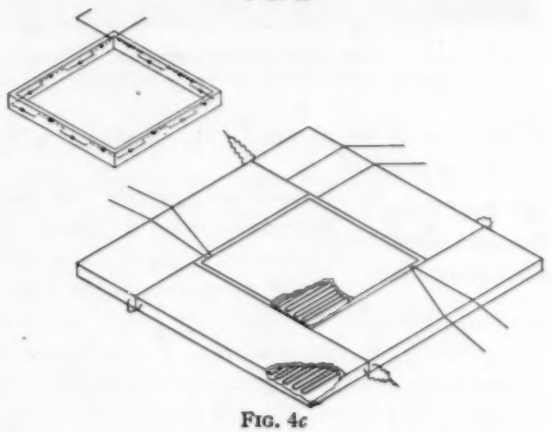

FIG. 4*c*

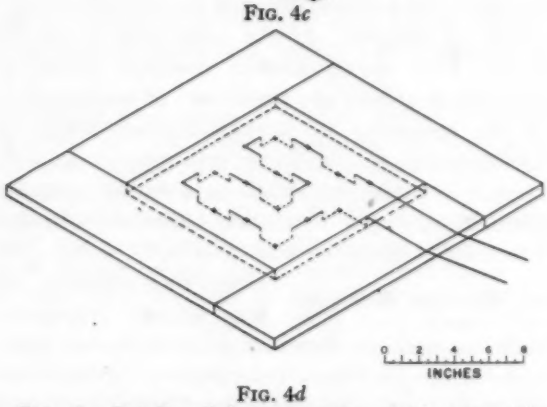

FIG. 4*d*

FIG. 4.—Details of four elements of the assembly: 4*a*, the test specimen with thermocouples in place; 4*b*, the heatmeter; 4*c*, the calibrating heater and its insulator; 4*d*, the insulator below the calibrating heater.

differential thermocouple of sixteen junctions, also shown in detail in Fig. 4*c*. The purpose of this insulator and differential thermocouple is to minimize lateral heat exchange between center and guard sections of the calibrating plate and to indicate the condition of temperature balance between the inner edge of the guard section and the outer edge of the center plate, which is the condition for zero heat exchange between them.

(6) Inter-Plate Insulator Under the calibrating heater is located a layer of insulation $1^1/_2$ inches thick, made up from five pieces, the center one 10 by 10 inches and the four outer ones each 4 by 14 inches in size, so that none of the joints coincides with a joint in the calibrating heater above it. In the center section, a platinum-rhodium differential thermocouple of sixteen junctions is threaded back and forth from upper to lower face in the manner indicated in Fig. 4*d*, which shows this entire insulator in detail.

The material of which this insulator is composed is the same as that of Johns-Manville C–22 brick, but prepared in special shapes.

The purpose of this insulator and its differential thermocouple is similar to that of the small insulator between center and edge of the calibrating plate, namely, to minimize downward loss of heat from the center of the calibrating plate and to indicate the condition of zero loss in this direction. When the center section of the calibrating heater is surrounded on all four sides and below by surfaces at the same temperature as itself, all the heat energy developed in it and measured by the wattmeter must flow upward through the heatmeter and test specimen as is desired.

(7) Lower Blocking Heater The region of temperature equal to that of the lower face of the calibrating heater is established by another heating element which is referred to as the "blocking heater," for it blocks downward heat flow. This element consists of four Alundum plates with Nichrome elements exactly similar to and interchangeable with the elements forming the guard section of the calibrating plate. Instead of a separate heater in the center, however, the space is occupied by a block of insulation. To provide an isothermal surface, the four heating elements are covered by a plate of Allegheny 55 temperature-resistant steel, $^1/_2$ inch thick and 18 inches square. A layer of Micanite No. 666, $^1/_{16}$ inch thick, serves as electrical insulation between the Allegheny plate and the thermocouples in the insulator above it.

(8) Water-Cooled Stabilizing Plate below Blocking Heater The blocking heater rests on a $^3/_4$-inch layer of calcined Sil-O-Cel insulation, which serves to reduce the amount of power necessary to bring the blocking heater up to the desired temperatures. Below this insulation is a metal water-cooled plate, which helps to stabilize the temperature of the blocking heater and make it more nearly independent of the temperature of the room.

The whole assembly is supported by a steel plate, 18 by 18 and $^1/_2$ inch thick, which can be raised or lowered by three supporting threaded columns, so that the level of the Globars may be made to coincide with that of the Globar terminals regardless of the thickness of the test specimen.

(9) Thermocouples All thermocouple leads are brought out of the assembly to two terminal plates on opposite sides of the frame, one of which is shown in Fig. 2. Here the thermocouples are joined to the permanently installed copper lines which lead to the potentiometer in another room.

A Leeds & Northrup Type K potentiometer is used for measuring all thermocouple potentials, all the temperature thermocouples and the differential couples in the insulators of the calibrating heater group being read to the nearest 10 microvolts, while the differential thermocouple in the heatmeter is read to the nearest unit of microvoltage.

(10) Power Leads The power leads from the heaters of the calibrating group are brought out at right angles to the thermocouples to two terminal boards. Current lines connect with the switchboard where a rheostat is provided for each line, along with means for inserting a multirange ammeter in any circuit.

Current is supplied to the lines from an autotransformer having steps of 4 volts from 48 to 110 volts.

The line feeding the center of the calibrating heater has an additional shunting switch and series circuit terminating at a switchboard in another room where the wattmeter circuit is

located. The potential connection from this heater plate is likewise brought to the same point, where there is available a set of three Weston Model 310 wattmeters, each having three ranges which permit the power measurement to be made on a full-scale range of either 4, 8, 16, 30, 60, 120, 250, 500, or 1000 watts.

Further means are provided for making a correction for the disturbance in the circuit caused by opening the shunt switch and sending the current through the wattmeter current coils and also for the power drain of the wattmeter potential coils.

Current for the Globars is supplied also from the small switchboard shown in Fig. 1, the same autotransformer being used as for the heater-plate circuits. This autotransformer has a current capacity on any tap of 100 amperes or a total capacity of 11 kilowatts.

The power is supplied from a 220-volt 60-cycle generator driven by a synchronous motor, the output voltage of the generator being regulated to $\pm 1/2$ per cent by a high-speed Thyratron regulator. A stand-by supply circuit is available, consisting of a General Electric saturated-core type regulator operating to control the voltage of the 440-volt supply line.

(11) Exterior Frame The exterior frame of the apparatus is made in two parts. The upper portion, which carries the Globar terminal assemblies, is counterweighted and may be raised to give access to the interior. The lower portion rests upon the floor but supports the interior assembly at a convenient height. The outer frame and panels serve also as a container for the insulating powder (Johns-Manville Superbrick, ground and passed through a 40-mesh screen) with which the 9-inch space between the interior assembly and the outer parts is filled.

III. Operation of the Apparatus

(1) Obtaining Thermal Equilibrium Assuming that the apparatus has been set up as shown in Fig. 3 and that a test is being started, the operation of the apparatus proceeds somewhat as follows. Power is applied to the Globars (which can all be connected in series, pairs in series, threes in series, or all six in parallel) in amount sufficient to bring the upper face of the test specimen to the temperature desired. Power is also applied to the center area of the calibrating heater to bring it to some temperature higher than that of the upper face of the specimen (usually 200 to 400°F higher) as may be roughly calculated by estimating the conductivity of the test specimen. Power inputs to the guard section of the calibrating heater and to the blocking heater are then adjusted to steady all temperatures and to bring both differential thermocouples in the calibrating group to zero reading within 20 microvolts. In general, the time necessary for securing such a condition of temperature balance and thermal equilibrium is about 48 hours, but in cases where the test specimen is undergoing physical change such as shrinkage or loss of CO_2, somewhat longer periods are required before absolute thermal equilibrium can be obtained.

(2) Thermal Equilibrium at High Temperatures Equilibrium points are taken at a series of temperatures up to a maximum of about 1600°F at the heatmeter. Above this temperature the electrical insulating value of the Alundum becomes such that the thermocouples and differential couples pick up irregular, stray currents from the heating circuits, which prevent accurate balancing of temperatures between the heating elements and which affect the measurement of temperatures and heat flow.

To continue the conductivity test to higher temperatures it is then necessary to reverse the direction of heat flow by increasing the temperature of the Globar heaters to a value greater than that of the calibrating heater group. Measurement of the power input to the calibrating heater is no longer necessary, nor is it essential that the blocking heater be maintained at the same temperature as the calibrating heater. However, the guard section of the calibrating heater should be balanced in temperature against the center of the unit in order to provide an isothermal plane below the test specimen.

The rate of heat flow during this portion of the test can be calculated from the readings of the heatmeter and its previously obtained calibration, as will be outlined later.

Conductivity points can be determined with downward heat flow at the same mean temperatures as the higher temperature points taken with upward flow as a means of checking one type of operation against the other.

As the hot-surface temperature of the sample

is raised toward its maximum of 2600°F, it will be necessary to allow the temperature difference between hot and cold faces of the sample to exceed the 200° or 400° used for the lower temperature points if the temperature of the heatmeter is not to exceed 1600°. If desired, the temperature of the heatmeter can be run up to 1800° or 1900° to obtain increased mean temperatures within the sample, with consequent necessity for a short extrapolation of the heatmeter calibration curve and also for replacement of the insulation between center and guard sections of the calibrating heater after the test.

(3) Assemblage to Obtain More Rapid Operation A variation of the foregoing method of operation becomes possible when the heatmeter has been well calibrated. If the apparatus assembly is modified to conform with that shown in Fig. 5, that

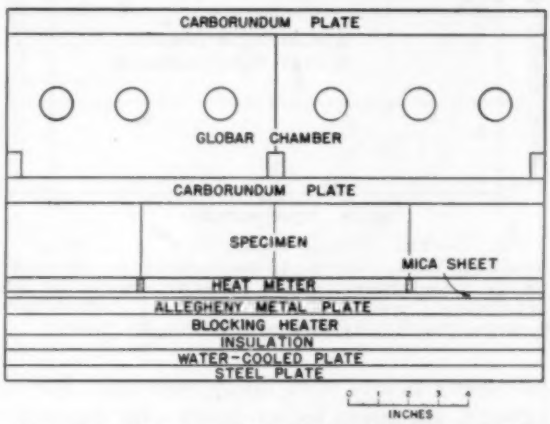

FIG. 5.—Vertical section of the interior apparatus assembly as set up for testing with the calibrated heatmeter only.

is, if the calibrating heater and the layer of insulation below it are removed, then the entire conductivity-temperature curve can be obtained with downward heat flow and the use of the calibrated heatmeter. Operation in this manner is more rapid, for the necessity of balancing temperatures of the different elements is avoided and, furthermore, in testing materials of relatively high thermal conductivity, such an arrangement of the parts would probably prove to be absolutely necessary so that the total thermal resistance below the heatmeter might be kept down to a value such that the desired portion of the total temperature drop between Globars and water-cooled plate would appear across the test specimen. The curves shown in Fig. 9 were all determined using this variation of the method of test.

(4) Calculations The conventional formula for steady state parallel heat flow is employed:

$$k = \frac{qL}{A(t_2 - t_1)}$$

(using the symbols of the A.S.A.)

k = thermal conductivity (B.t.u./hour/sq. ft./°F/in. thick)
q = heat flow (B.t.u./hour)
L = thickness of specimen (in.)
A = area of specimen (sq. ft.)
t_2 = hot surface temperature (°F)
t_1 = cold surface temperature (°F)

The energy input to the center of the calibrating plate is measured in watts, which must be multiplied by 3.415 to convert it into British thermal units per hour. The area of the center of the calibrating plate and the center of the heatmeter may be assumed to include half the width of the space between each and the associated guard, which will be 8.75 inches square, or $8.75 \times 8.75/144$ square feet. This factor may be combined with the 3.415 to give as a working formula,

$$k = \frac{6.42\ WL}{(t_2 - t_1)}$$

where W represents the power in watts.

In calibrating the heatmeter, the watts passing through its total area are known for each equilibrium point, as well as its temperature and the electromotive force reading of its differential thermocouple. Since at any given temperature of the plate the electromotive force of the differential thermocouple may be assumed to be directly proportional to the total heat flow in watts (for the thermal resistance of the plate and the thermal electromotive force of the differential couple may be taken as constants when considering only one temperature) it is convenient to divide the total electromotive force into the watts heat flow and to plot this quantity (watts per millivolt) as a function of the temperature of the heatmeter for use as the calibration curve. The results that have been obtained to date in calibrating the heatmeter are shown in Fig. 6. There has been no observable trend of the points toward generally higher or lower values due to age or use of the meter.

(5) Criterion of Thermal Equilibrium In the operation of any thermal conductivity apparatus, the criteria ordinarily used to judge the attainment of ther-

mal equilibrium and temperature balance are important. The criterion used in the present case for temperature balance between the parts of the calibrating group is that both differential thermocouples must read within ±20 microvolts of zero during the final six hours of equilibrium.

A simple calculation, involving the thermal

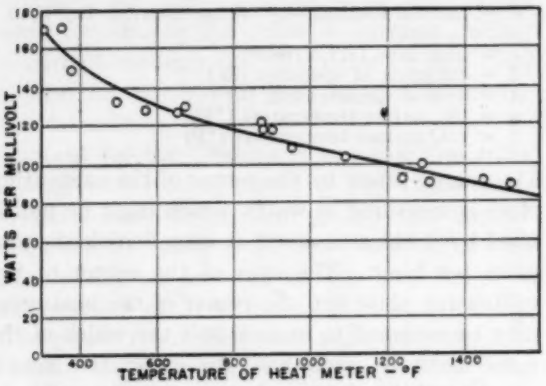

FIG. 6.—Calibration curve for the heatmeter.

electromotive power of the differential couples and the conductivities of the insulators in which they are embedded, shows that the error in measurement of the heat flow due to heat interchange between guard and center of the calibrating plate and between the latter and the blocking plate, under such conditions of balance, will probably be less than $1^1/_2\%$ of the total heat flow.

The criterion regularly used in this work to judge the attainment of thermal equilibrium is that the reading of each thermocouple on hot and cold faces of the test specimen must remain within ±20 microvolts of its average value during the last six hours of the run, all readings being taken at two-hour intervals.

NOTE: A standard platinum-rhodium thermocouple certified by the U.S. Bureau of Standards is kept in this laboratory and at frequent intervals a substandard thermocouple is checked against it. This substandard couple is used to standardize the couples which read hot- and cold-face temperatures of the test specimen in this test, as well as for standardization of other platinum-rhodium thermocouples used in this laboratory. Equipment is likewise at hand and used at frequent intervals for testing such couples for inhomogeneity and for annealing them before calibration.

A sight hole has been provided, through which an optical pyrometer can be sighted downward through the Globar chamber and Carbofrax plates upon the upper face of the test specimen. In every instance where such a reading was taken, it was found to check the temperature as read by the thermocouples to within the expected error of the optical pyrometer.

IV. Some Typical Results

(1) Sample No. 1 In Fig. 7, curve *B* is the result obtained in testing a well-known refractory insulating brick. The

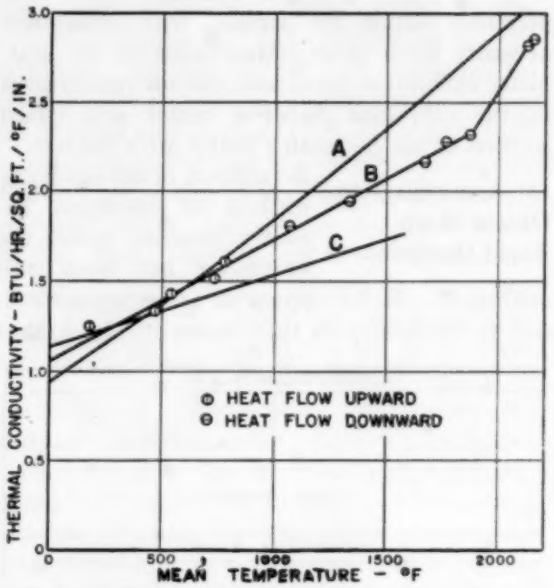

FIG. 7.—The thermal conductivity of a refractory insulating brick. Curve *A*, conductivity as advertised by the manufacturer; Curve *B*, as determined by this apparatus; Curve *C*, as determined in a medium temperature conductivity apparatus in this laboratory.

five lower points were taken with heat flowing upward, the seven higher points with downward heat flow.

Curve *C* in the same figure was determined in a different type of apparatus,[1] with a sample of the same material about $2^1/_2\%$ lighter in density, the apparatus being modified by the addition of heater plates on the cold faces of the test specimens. The latter apparatus does not directly include the effect of cracks between brick in its results. These two facts account, at least in part, for the differences between the two curves. Curve *A* is that advertised by the manufacturers of this material.

(2) Sample No. 2 In Fig. 8, curve *B* is the result of a test on a high-temperature insulating brick. The order in which the points were taken is indicated by the number adjacent to each, the first four having

[1] M. L. Hartmann, O. B. Westmont, and C. E. Weinland, *Proc. A. S. T. M.*, **28** [II], 820–47 (1928).

been taken with heat flowing upward, the remainder with downward flow.

Curve *A* is the result of a test on the same brand of material (but of density $3^1/_2\%$ greater) run in the apparatus referred to.[1]

This material exhibited much more shrinkage during the test than any other that has been run to date; the cracks between the brick after the test had opened to approximately $^3/_{16}$ inch wide on the hot face. Likewise the conductivity curve had risen proportionately higher at the high-temperature end though the upward break of the curve was less abrupt than in most of the cases observed thus far. The logical conclusion

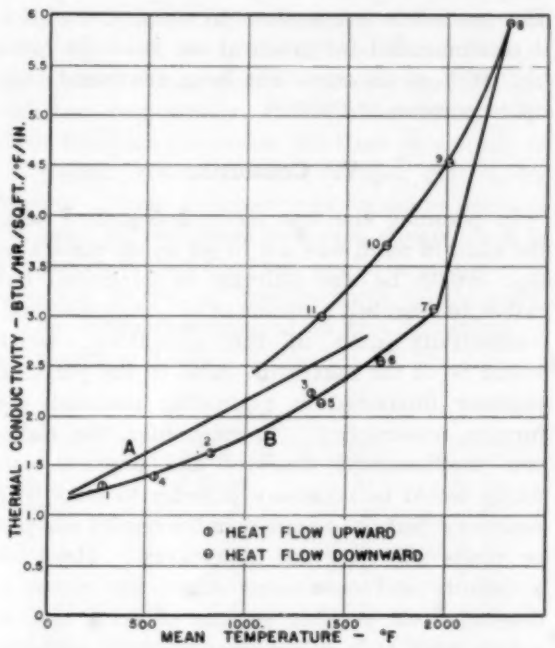

FIG. 8.—The thermal conductivity of a high temperature insulating brick. Curve *A*, as determined in a medium temperature apparatus in this laboratory; Curve *B*, as determined in this apparatus; the numbers give the order in which the points were determined.

that the steep upward trend at the high-temperature end of the curve was due to rapidly increasing heat transfer through the cracks was further confirmed in this case by the "down" branch of the curve, taken with successively lower temperatures, which at the low end indicated that a permanent change had taken place in the test specimen. The possibilities of the permanent change being in the calibrations of heatmeter or thermocouples were eliminated by subsequent checks upon them.

(3) Effect on Conductivity of Exposure of Sample to High Temperature

The case shown here is an exaggerated one, but it illustrates clearly the difference which may exist between the conductivity curve for a given material taken with successively increasing temperatures and one taken with the maximum first, followed by successively lower points. However, the "down" curve is not in every case higher than the "up" branch for there are several types of insulating materials, notably those containing

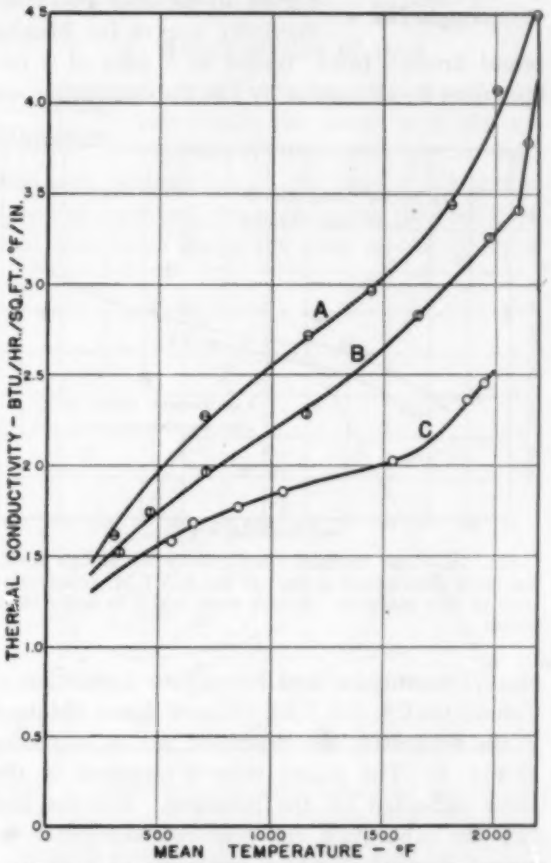

FIG. 9.—The thermal conductivity of three refractory insulating brick. Curves *A* and *B*, materials not of Johns-Manville manufacture; curve *C*, Johns-Manville C–22 brick.

magnesium carbonate, the thermal conductivities of which are reduced by prior subjection to high temperatures. The cases in which such a "down" conductivity curve gives a more truthful representation of the behavior of any high-temperature insulating material in use are rare indeed, so any such curve should in general be regarded as a misrepresentation of the material.

(4) Sample No. 3 Figure 9 shows conductivity curves for three refractory insulating brick, all taken with the use of the calibrated heatmeter and without the calibrating plate and insulators, which had been removed from the assembly. Curves *A* and *B* are for materials not of Johns-Manville manufacture, while curve *C* represents the conductivity of C–22 brick. The tendency of the curves to turn upward at the high-temperature end is clearly in evidence here, as it was in the two previous cases.

(5) Sample No. 4 Figure 10 includes two conductivity curves for Mexko brand fireclay brick, tested as a part of a cooperative investigation by the Subcommittee on

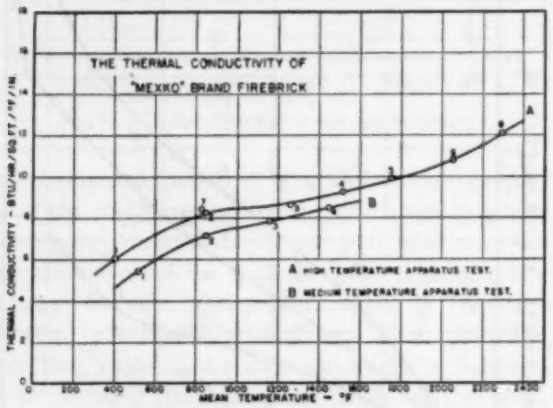
THE THERMAL CONDUCTIVITY OF
"MEXKO" BRAND FIREBRICK
A HIGH TEMPERATURE APPARATUS TEST.
B MEDIUM TEMPERATURE APPARATUS TEST.
MEAN TEMPERATURE — °F

FIG. 10.—The thermal conductivity of Mexko brand fire brick determined as part of the A.S.T.M. coöperative tests of this material. Points were taken in order numbered.

Heat Transmission and Refractory Insulation of Committee C8, A.S.T.M. Curve *A* was obtained in the apparatus here described, set up as shown in Fig. 5. The points were determined in the order indicated by the numbers. For the last two the calibration curve of the heatmeter required extrapolation to a maximum of 2050°F.

Curve *B* was determined in the medium temperature apparatus referred to previously,[1] set up with Nichrome-faced heaters on the cold face of each of the two identical test specimens. The fact that Curve *A* is higher than *B* can be explained in part at least as due to the heat transmission through the cracks between the brick which constituted the test samples in the high-temperature apparatus, this factor being absent in the other test.

In all of the results shown for insulating materials the limitation of the curves to 2200°F does not mean that the materials themselves can not be used at higher temperatures, for in all cases except that of C–22 brick the high points on the curves were taken with hot-surface temperatures on the sample of 2500 to 2600°F. The maximum temperature to which C–22 brick is recommended for practical use is of the order of 2100°, so its curve has been continued only up to a mean of 2000°F.

V. Conclusion

In planning the test method described here, the ideal in mind was not to set up an apparatus that would be the ultimate in precision, but rather to establish a means of obtaining thermal-conductivity data in the laboratory, which would be of the maximum value to the practical engineer interested in evaluating materials for furnace construction. Consequently, the elaborate mathematical analyses and physical tests which would be necessary in order to state with authority that the accuracy of the results was plus or minus $x\%$ were not undertaken. However, a definite and continuous effort was made to determine all possible sources of error and to reduce each to a minimum consistent with the end in view.

The applicability and usefulness of this apparatus in testing high-temperature insulators and insulating refractories are regarded in this laboratory as having been established.

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THE INFLUENCE OF COMPOSITION OF THE FELDSPAR CONSTITUENT ON THE PROPERTIES OF A PORCELAIN BODY*

By Joseph H. Chilcote

ABSTRACT

An investigation is presented covering industrial application of potash soda, lime-soda feldspars as represented by commercial microcline, albite, and andesine, respectively, and various mixtures of these feldspars were chosen on the basis of a study of the potash, soda, lime-soda feldspar system. These feldspars and mixtures were incorporated in a typical porcelain body and were prepared and formed according to normal practice for a plastic body.

I. Introduction

This investigation covers industrial application of potash, soda, and lime-soda feldspars as represented by commercial microcline, albite, and andesine, respectively, and various mixtures of these feldspars chosen on the basis of a study of the potash, soda, lime-soda feldspar system, by Martz.[1] These feldspars and mixtures were of the same pulverization and were incorporated in a typical porcelain body and prepared and formed according to normal practice for a plastic body.

The feldspars employed in this investigation are shown in Table I.

TABLE I

	Microcline feldspar (%)	Albite feldspar (%)	Andesine feldspar (%)
SiO_2	65.36	68.00	62.56
Al_2O_3	18.45	20.33[a]	23.88[a]
Fe_2O_3	0.13	0.07	0.06
CaO	0.04	0.35	4.98
MgO	0.06	0.04	0.01
K_2O	12.76	0.30	0.58
Na_2O	2.43	10.72	7.95
TiO_2	0.01		
P_2O_5	Trace		
Ignition loss	0.28	0.16	0.23

[a] The TiO_2 and P_2O_5 of the albite and andesine feldspars are calculated with the Al_2O_3.

The various bodies studied have the following compositions:

Feldspar composition	Identifying numbers												
	1	41	66	69	87	97	106	108	126	138	149	211	231
Microcline	100	60	50	45	40	35	30	30	25	20	20	0	0
Albite	0	20	0	45	20	40	70	60	50	75	20	100	0
Andesine	0	20	50	10	40	25	0	10	25	5	60	0	100

Ky. ball (No. 4)	20%	constant for all compositions
Fla. kaolin (Lake)	15%	
Ga. kaolin (Klondike)	15%	
Flint	30%	
Feldspar	20%	

The bodies were fired in a laboratory downdraft kiln, the firing procedure being as follows: to cone 7^3 in 24 hours, to cone 9^2 in 24 hours, to cone 10^2 in 28 hours, and to cone 12^3 in 28 hours.

II. Interpretation of Data

(1) Firing Shrinkage At cone 7^3 the firing shrinkages were practically the same with the exception of members in the high lime-soda feldspar area. At cone 9^2 all shrinkages had increased, the members in the high lime-soda area being about the same as the others at this temperature. At cones 10^2 and 11^3 only the 100% lime-soda feldspar body showed less shrinkage than the remainder of the group. At cone 12^3 the eutectic member between microcline and albite or potash feldspar and soda feldspar showed pronounced bloating due to overfiring.

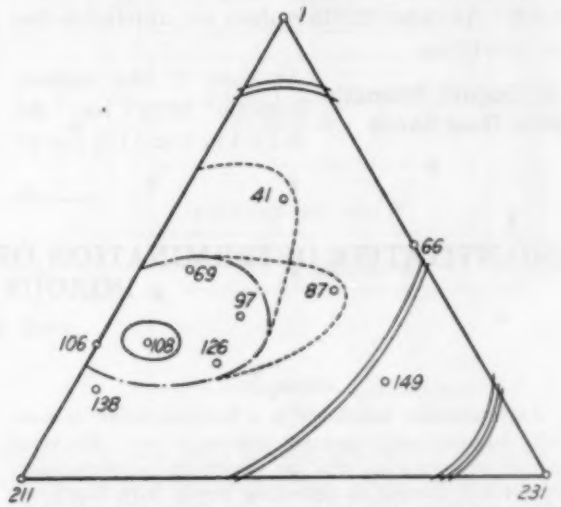

FIG. 1.—Body 108, minimum absorption and impact strength (before and after heat shock); maximum translucency and modulus of rupture.

Body 231, opposite extreme from 108 in all tests.

Body 149, next to 231 in modulus of rupture and impact strength (before and after heat shock).

Body 1, next to 231 in absorption and translucency.

Body 41, included with second group only in impact strength after heat shock.

Body 87, included with second group only in impact strength before heat shock.

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division). Received January 5, 1933.

These data are abstracted from a thesis, Ohio State University, 1932.

[1] J. A. Martz, *Jour. Amer. Ceram. Soc.*, **16** [7], 299–304 (1933).

(2) Absorption The absorption data support the firing shrinkage data quite definitely.

(3) Translucency Maximum translucency was obtained at all temperatures with the potash, soda, and lime-soda ternary eutectic.

(4) Modulus of Rupture The ternary eutectic appears to give the maximum modulus of rupture at cone 7^3, cone 9^2, and cone 10^2. At cone 12^3 most of the values are erratic due to overfiring.

(5) Impact Strength before Heat Shock At cone 7^3 the bodies high in potash and lime-soda feldspars show the greatest impact strength and the ternary eutectic the least impact strength. The members or bodies surrounding the ternary eutectic body are also low in impact strength. Hence impact resistance decreases with increase in glass. At cones 9^2 to 11^3 the same general statements hold. At cone 12^3 the values are unreliable due to overfiring.

(6) Impact Strength after Heat Shock At cone 7^3 the ternary eutectic body has the minimum impact strength. The bodies containing the greatest amount of the lime-soda feldspar show the maximum impact strength. This statement also holds for cones 9^2, 10^2, and 11^3. At cone 12^3 the data are unreliable due to overfiring.

III. Conclusions

It is apparent that the body containing the ternary eutectic feldspar mixture (microcline 30%, albite 60%, and andesine 10%) develops more vitrification or glass than any of the other body mixtures. This is indicated by the low absorption, higher modulus of rupture, and also higher translucency produced at relatively lower temperatures. The tendency of the mixtures in the feldspar eutectic area to warp due to a higher quantity of glass suggests that the amount of this mixture necessary to produce vitrification is distinctly less than would be required for other feldspar mixtures.

The most valuable application of the foregoing data is the evidence presented that mixtures of the three feldspars may control, to a considerable extent, the properties of the body.

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QUANTITATIVE DETERMINATION OF AIR CONTENT IN PLASTIC CLAY OR POROUS BODIES*

By G. W. Lapp

ABSTRACT

An instrument mentioned in a previous paper[1] is more fully described with operating notes on it use. The voids in clay or porous material are eliminated by compression in a bomb having an operating piston with leak-proof packing. Air content is compressed into solution in the liquid present. By this means minute quantities of air or other data can be determined in a few minutes by direct reading. The test is made without change in state and is free from the errors of disintegration-by-heating methods.

I. Description of Instrument

The pressure chamber is really a compression volumeter. It is shown in Fig. 1. The body is a thick-walled cylinder closed at the bottom. In the open top end is a leak-proof operating piston or plug accurately fitted in its cylinder. The piston consists of two principal parts with a gasket disk between. The lower part or piston proper has a stem extending up through the thin annular gasket and held up by a nut that can be adjusted to produce a small initial pressure on the gasket.

The second part of the piston is a cylindrical pusher close-fitted to the cylinder bore at its lower end with a cap on the top to which pressure is applied. This type of packing can be made leak-proof and have but little friction. It functions as follows: The specimen is immersed in liquid in the chamber below the piston. Force is applied on the cap down through the pusher through the packing to the piston. An equal total liquid pressure acts upwardly under the piston. Since the annular area of the packing

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division). Received February 5, 1934.

[1] G. W. Lapp, "The Vacuum-Slip Process of Removing Air from Clay Bodies," *Jour. Amer. Ceram. Soc.*, **11** [2], 61–67 (1928).

is about 10% less than the liquid area, the pressure per square inch on the packing is about 11% higher than the pressure per square inch in the liquid. Theoretically, the packing tends to squeeze down with this definite excess of pressure into the liquid space, however high the liquid pressure may be. The result is that there is no leaking with ordinary care. This type of packing has been used up to 100,000 pounds per square inch and Professor Bridgman of Harvard University has used it at pressures upward of 500,000 pounds per square inch. He developed the packing and has used it many years for high pressure experimentation.

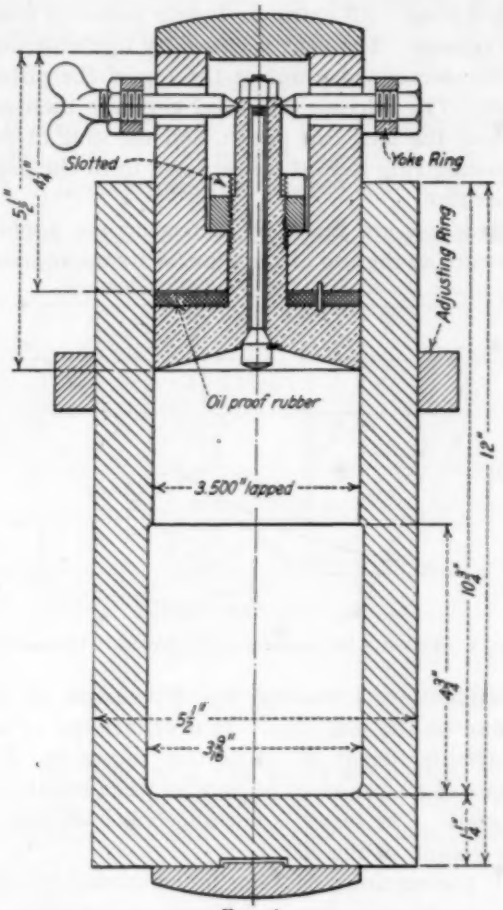

FIG 1

To indicate the exact amount that the piston is depressed when pressure is applied, the application of a dial gage has been developed which reads in ten-thousandths inch, mounted as shown in Fig. 2 by means of a yoke around the piston plug. It will be seen that the pivots attaching this yoke lever ring go through the pusher member to the center stem of the piston registering the movement of the piston itself. By means of this mounting of the gage the movement of the plug at its axis only is indicated which is at the line of intersection between the pivot centers in one direction and the line between the fulcrum strut and the tip of the gage in the other direction. By this scheme cocking of the plug in the hole does not affect the reading of the gage. At the same time the sensitivity of the gage is multiplied by two. With a sample of clay of 50 cubic inches volume in the cylinder one ten-thousandths inch on the dial gage reading indicates a compression of one thousandth per cent of the clay volume.

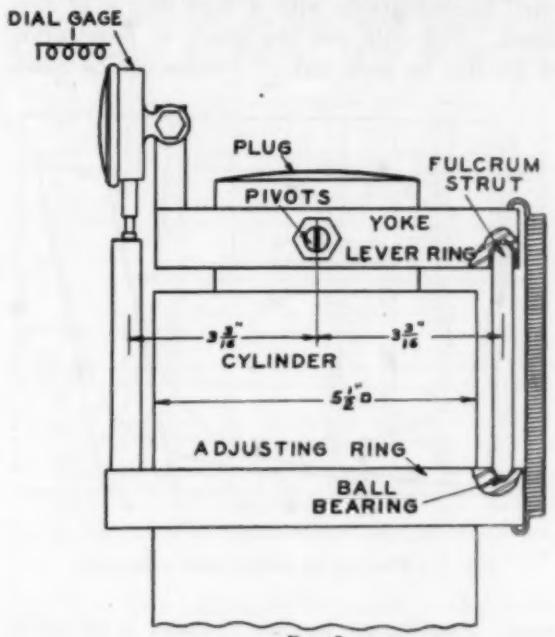

FIG. 2.

The friction of the packing in the cylinder wall is found to be approximately 4% of the total pressure applied. This friction is readily determined by increasing the pressure by steps, noting the depresssion readings on the dial gage, and then gradually letting the pressure down, noting the readings on the gage. The pressure difference between these two curves is twice the friction of the packing. Friction is practically proportional to pressure. To compensate for this friction the cylinder area can be made about 4% smaller than the nominal area which, in the case shown, is ten square inches. Thicker packing causes greater friction and thinner packing can be used to decrease friction as desired.

In this way the instrument becomes direct reading with no errors to be compensated for.

II. Making Volume Determinations

This instrument was first used merely as a pressure chamber for the impregnation of porcelain. The depth of penetration of fuschine dye could be observed utilizing pressures up to 10,000 pounds per square inch. It was noted that the plug rose after the compression run to the original zero point before compression, indicating that the packing was amazingly free from leakage. This fact made it possible to obtain quantitative volume determinations with a high degree of precision. Not only can the depth of penetration of the dye be seen, but its volume can be measured. Another use for this chamber is the exact determination of the air content in plastic clay or in slip merely by compressing a known volume of the specimen in the chamber. Still another use is the determination of elastic volume compressibility of liquids or solids. For example, when oil is used as the liquid medium in the chamber a greater depression of the plug is observed than when water is used. Solids in general are still more rigid in volume.

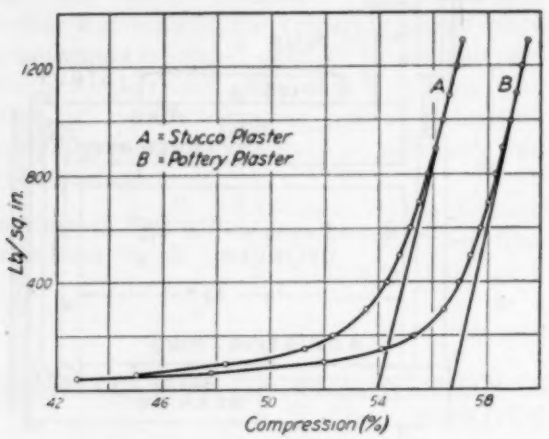

FIG. 3.—Porosity by compression volumeter.

The procedure in making a volume determination is as follows: The sample of standard or determined volume is immersed in very light lubricating oil in the cylinder, avoiding bubbles. In testing plastic clay it is convenient to stick a rod dipped in oil into the clay which acts as a handle for lowering it into the cylinder and for swirling it around once or twice to release any possible air bubbles that may cling to any of the surfaces. The oil is next adjusted to a standard measured working level about three inches from the top of the cylinder. The piston and its packing are assembled under oil, and the plug and cylinder wall are then coated with lubricating oil to fill the space between the piston and the cylinder wall. As the plug enters the cylinder the air pocket above the oil level is expelled into the center vent until oil is seen coming out at the top of the stem. All extra air is thus removed from the system. The vent is closed by tightening up on the center valve nut at the top of the piston stem. The fulcrum yoke and gage are then attached, the plug cap put in, and the snug fitting adjusting ring tapped up or down until the gage reads zero.

Readings are taken by increasing the applied pressure at the top of the plunger by appropriate increments and reading the depressions of the piston on the dial gage. It is convenient to use a definite height of oil as this causes the line slopes of all graphs to be parallel when results are plotted. The result is not affected, however, by the volume of the oil.

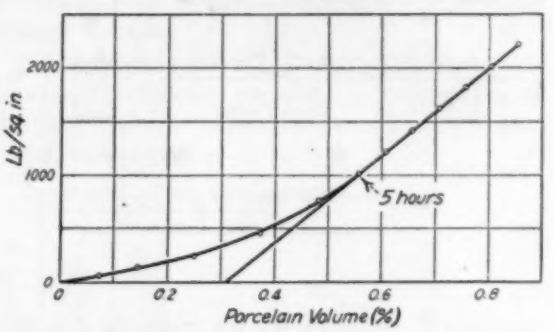

FIG. 4.—Porosity by compression of underfired porcelain.

If the specimen contains no compressible voids the compression line will rise from the origin in a straight line at a definite slope, and return along the same line when the pressure is decreased, showing that the material is elastic and that compression is proportional to pressure applied. If, however, there is even a minute trace of air in the specimen the applied pressure will first cause its elimination by dissolving this gaseous part of the volume by solution in the liquid present. Above this point of complete absorption of the gas content the line will become straight at the same slope that it would have taken had no voids been present. By continuing the straight line down to the base the intercept on the base line

can be measured and considered a measure of the volume of gas present. In ordinary cases, such as plastic clay and for gross communicating porosity, the time of compression occupies only a few minutes. For very slightly porous bodies, however, as shown in Fig. 4, it will be noted that the plug continues to settle for hours at a slow rate until finally the graph rises definitely as a straight line. This point of tangency between the curved and the straight line indicates definitely the point at which absorption is complete.

III. Result of Tests

It is striking to note in the case of highly porous bodies, such as light pottery plaster as shown in Fig. 3, that the pressure required fully to impregnate the finer porous structure is about as high as in Fig. 4. By judging such details during the compression one may come to know much about the nature of the porous structure. At the other extreme is that slight porosity which is slow and difficult to determine by boiling and soaking or even by the use of a vacuum (Fig. 4). In this case it can be seen just how far the dye penetrated, and the total porosity can also be measured quantitatively, although only after several hours at high pressures. It sometimes requires a period of years for this slight porosity to be detected by absorption of moisture and failure in service.

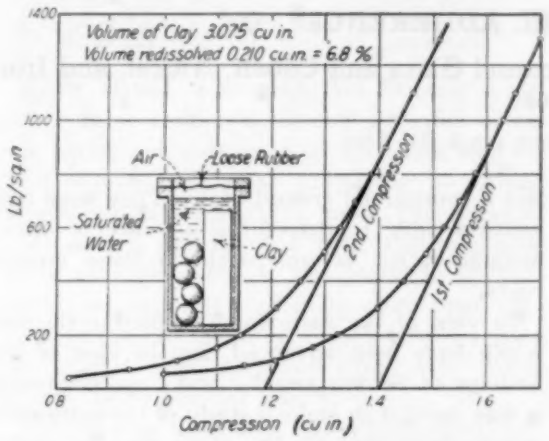

FIG. 5.—Capacity of plastic clay from evacuated slip to redissolve air.

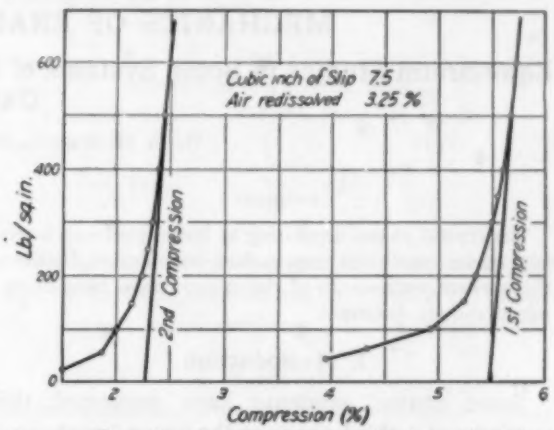

FIG. 6.—Capacity of vacuum-treated slip for redissolving air.

IV. Determination of Air-Absorbing Capacity

For a dozen years the writer has removed air from the slip with a vacuum, taking out not only the bubble air content, but also boiling out the gas dissolved in the slip. This gives to the slip and to the filter-press cakes pumped from this slip the ability to absorb or to redissolve a considerable amount of air. This amount of air absorbed can be considered as a hidden or negative air content. To determine this amount quantitatively, a device can be used as shown in Fig. 5.

A charge of water which has been saturated with air, the sample of plastic clay, and steel balls to reduce the clay to a slip later on are put into a metal cylinder. A bubble of air is left above the water level and the lid (a loose rubber diaphragm) is clamped down, insuring equalization of pressure inside and outside of the cylinder. Room temperatures are kept fairly constant to avoid changes in solubility. This air-tight assembly is then immersed in water in the main compression cylinder and a compression curve is obtained as shown at the right in Fig. 5. The first compression indicates the volume of the air space to be 1.41 cubic inches. The inside cylinder is then tumbled for several hours attached to a laboratory pebble mill to reduce the plastic clay to a slip and to mix in the air volume, allowing as much as possible to be finely dispersed and dissolved. A second compression is made showing the reduced air content to be 1.2 cubic inches, indicating an absorption and re-solution of 0.210 cubic inch which is 6.8% of the original volume of clay.

Similarly, the absorbing power of vacuum-treated slip (see Fig. 6) is determined as 3.25% of the volume of the slip. This is very striking as the slip contains more water per unit volume and it would appear that it should dissolve more

air. The opposite is true, however; the plastic clay appears to absorb a greater volume of air. The dissolving power seems to be increased by the particles present in the water. This phenomenon is being further investigated to discover the way in which unexpectedly large volumes of air are held in the clay. It may be that the air content is reduced to microscopic bubbles having such small area and such high pressure due to surface tension that the air is forced into solution.

V. Conclusion

This instrument lends itself conveniently to a wide range of precision determinations of compressibility. It may be used to determine gross porosity or a very slight degree of porosity. It may be used to determine the void content in any porous or plastic material. So delicate are its indications that it is possible to determine the slight volume compressibility of liquids and solids.

An especially valuable feature of its operation is the fact that, by the application of pressure, one can force the impregnation of very small pores to an end point which indicates a complete penetration of the porous structure.

LAPP INSULATOR COMPANY, INC.
LEROY, NEW YORK

MECHANICS OF ENAMEL ADHERENCE. IX*

Equilibrium Studies in Some Systems of Enamel Glass and Cobalt, Nickel, and Iron Oxides†

BY G. H. SPENCER-STRONG AND R. M. KING

ABSTRACT

The crystal phases separating at the enamel-iron interface under conditions approaching equilibrium between the various components of the system have been determined and are discussed.

I. Introduction

Some enamel students have suggested the presence of a third phase at the ground coat-steel interface; some have postulated the presence of an iron-oxide layer; while others have advanced the theory that this phase is composed of metallic cobalt. Schwartzwalder[1] and Spencer-Strong[2] were able to isolate and identify by X-ray analysis a metallic precipitate of alpha-iron at the enamel-steel interface in the case of a cobalt-oxide ground coat, a nickel-oxide ground coat, and a commercial ground coat. They were not, however, able to detect the presence of either metallic cobalt or iron oxide in these ground coats.

In view of the varied and conflicting theories which have been advanced, and in view of the findings of Schwartzwalder and Spencer-Strong, it was decided to make a study of the saturation relationships between the three metallic oxides (Co_3O_4, Ni_2O_3, and Fe_2O_3) involved and an enamel glass.

II. Plan of Investigation

The plan of the investigation follows: (1) determining the saturation boundaries and the phase relationships along those boundaries of the three-component systems melted in nonmetallic (sillimanite) crucibles; (2) making a comparison of the phases found in nonmetallic crucibles with those present in metallic (steel) crucibles; and (3) determining the phases in some two-component systems (enamel-steel).

The systems included in the investigation were (1) Co_3O_4–Fe_2O_3–enamel glass, (2) Ni_2O_3–Fe_2O_3–enamel glass, (3) Co_3O_4–Ni_2O_3–enamel glass, (4) Co_3O_4–enamel glass, and (5) Ni_2O_3–enamel glass.

III. Materials and Equipment

An enamel glass was selected which repre-

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† Presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of The Ohio State University, 1934.

[1] Karl Schwartzwalder and R. M. King, "Mechanics of Enamel Adherence, VI: A Petrographic, Metallographic, and X-ray Study of Enamel-Metal Contact Zones," *Jour. Amer. Ceram. Soc.*, **15** [9], 483 (1932).

[2] (*a*) G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence, V: A Study of Enamel-Metal Contact Zones by Chemical Methods," *ibid.*, p. 480 (1932).

(*b*) G. H. Spencer-Strong, J. O. Lord, and R. M. King, "Mechanics of Enamel Adherence, VII. Further Studies of Enamel-Metal Contact Zones by Microscopic and Metallographic Methods," *ibid.*, p. 486 (1932).

sented in composition a balanced average of more than thirty commonly used ground-coat formulas. Raw materials used in the glass as well as the metallic oxides required were of first-quality commercial grade, similar to those used in the best commercial practice.

TABLE I

RAW BATCH COMPOSITION OF ENAMEL GLASS

Material	(%)
Borax	33.5
Potash feldspar	28.9
Flint	19.8
Soda ash	7.7
Fluorspar	5.1
Sodium nitrate	5.1

The glass had the following molecular formula:

$$\left.\begin{matrix}0.904\ Na_2O\\0.050\ K_2O\\0.045\ CaO\end{matrix}\right\}\ 0.050\ Al_2O_3\ \left\{\begin{matrix}0.045\ F_2\\0.615\ SiO_2\\1.683\ B_2O_3\end{matrix}\right.$$

Eight glasses were made up for the study. Six of these contained various amounts of cobalt oxide, one contained nickel oxide, and the other was a base glass containing no oxides. Because of its tendency to cause effervescence, cobalt oxide was smelted with the raw glass batch when possible. It was found to be difficult to retain melts containing more than 29% Co_3O_4 in the crucible long enough to get a good frit. Nickel oxide and iron oxide were added directly to the blended glasses.

Fusions were made in a specially designed furnace fired with a laboratory blast lamp. This furnace reached its operating temperature very rapidly and was able to maintain this temperature for a period of hours with little variation. Since it was desirable to use a considerably higher temperature than that ordinarily used in enameling practice in order that the systems reach an approximate equilibrium as rapidly as possible, the furnace was operated at a temperature of 2500°F. At this temperature cobalt glasses reached approximate equilibrium in two hours or less. Nickel-oxide glasses required from three to four hours because of their much greater viscosity.

Unglazed sillimanite crucibles were used for all fusions in nonmetallic crucibles. Iron crucibles of special design to facilitate the making of metallographic sections were made from enameling steel. Because of the small size of the iron crucibles it was difficult to retain a batch due to effervescence. Hence it was necessary to premelt batches to be heated in these crucibles in a sillimanite crucible and then to pour the molten glass into the iron crucibles. The heating time of the melts in iron crucibles was thirty minutes.

All fusions were air-chilled. Glasses were examined by metallographic polished section, by petrographic microscope, and, when required, by X-ray. The latter apparatus was of the General Electric diffraction type using the Coolidge tube. Analysis was made by the fine powder method.

IV. Nonmetallic Crystal Phases

The systems (1) Co_3O_4–Fe_2O_3–glass, (2) Ni_2O_3–Fe_2O_3–glass, and (3) Co_3O_4–Ni_2O_3–glass (see Fig. 1), were found to contain nonmetallic phases at saturation as shown in Table II.

TABLE II

NONMETALLIC CRYSTAL PHASES

System No. 1	System No. 2	System No. 3
Fe_2O_3	Fe_2O_3	CoO
Fe_3O_4	Fe_3O_4	NiO
$CoO:Fe_2O_3$	$NiO:Fe_2O_3$	
CoO	NiO	

These phases were encountered in both metallic and nonmetallic-crucible melts. Table III shows the optical characteristics of the nonmetallic

TABLE III

MICROSCOPIC IDENTIFICATION OF NONMETALLIC PHASES

Phase	Crystal form	Color	Index	Magnetism
Fe_2O_3	Plates	Reddish brown	2.91, 3.01	None
Fe_3O_4	Octahedrons	Black opaque	*	Pronounced
$CoO:Fe_2O_3$	"	Blue edges opaque	*	Pronounced
$NiO:Fe_2O_3$	"	Green edges opaque	*	Pronounced
CoO	"	Bright blue	*	None
NiO	"	Green	2.18	None

* Not given in the literature; positive identification by X-ray only.

TABLE IV

X-RAY IDENTIFICATION OF NONMETALLIC CRYSTAL PHASES

Phase	Crystal system	a_0 (found)	a_0 (given)*
Fe_2O_3	Hexagonal	Identified by comparison of d/n	
Fe_3O_4	Cubic	8.426	8.417
$CoO:Fe_2O_3$	"	8.359	8.359
$NiO:Fe_2O_3$	"	8.36	8.340
CoO	"	4.245–4.266	4.250
NiO	"	4.17	4.170

* Ralph W. G. Wyckoff, THE STRUCTURE OF CRYSTALS, 2nd Ed., The Chemical Catalog Co.

TABLE V

X-RAY ANALYSIS OF GLASS CONTAINING 40% Co_3O_4

(Camera radius = 20.337 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face	a_0
1	10	5.879	0.14454	2.4646	111	4.269
2	10	6.821	0.167699	2.1269	100 (2)	4.2538
3	10	9.711	0.238752	1.5011	110 (2)	4.2458
4	5	11.424	0.280867	1.2807	311	4.2476
5	4	11.970	0.294291	1.2241	111 (2)	4.2404
6	2	13.867	0.340930	1.0634	100 (4)	4.2536
7	2	15.135	0.372105	0.9764	133	4.2560
8	2	15.602	0.383587	0.9486	120 (2)	4.2423
9	2	17.149	0.421621	0.86750	121 (2)	4.2499
10	1	18.195	0.447337	0.8207	511	4.2645
11	Wk.	19.974	0.491051	0.7528	110 (4)	4.2585
12	"	20.973	0.515637	0.7200	531	4.2596
13	"	21.291	0.523455	0.7102	100 (6)	4.2612
14	"	22.578	0.55110	0.6736	310 (2)	4.2602
					Mean,	4.25447

Mean of all lines less 1, 5, and 8, 4.2545
Accepted value CoO, 4.250
Phase CoO

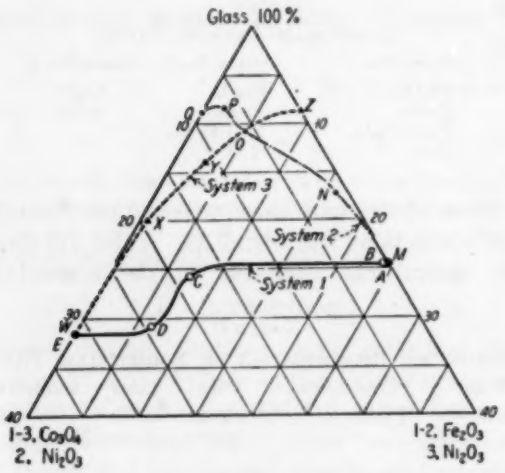

FIG. 1.

TABLE VI

X-RAY ANALYSIS OF GLASS CONTAINING 9% Ni_2O_3

(Camera radius = 11.311 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face	a_0
1	5	3.303	0.146008	2.44006	111	4.226
2	10	3.842	0.169835	2.10030	200	4.200
3	9	5.509	0.243524	1.47224	220	4.1634
4	4	6.461	0.285607	1.2600	311	4.1789
5	3	6.764	0.299001	1.199488	222	4.1551
6	1/2	7.845	0.346786	1.04449	400	4.17796
7	1	8.600	0.380161	0.95669	331	4.1701
8	2	8.828	0.390274	0.93312	420	4.1730
9	2	9.697	0.428654	0.85409	422	4.1842
10	1	10.382	0.458934	0.80135	333	4.1640
11	Weak	11.338	0.501194	0.73885	440	4.1796
12	"	11.919	0.526876	0.70599	531	4.1725
13	"	12.102	0.534966	0.69634	442	4.17804

Mean of all lines except 1 and 2, 4.172
Accepted value NiO, 4.170
Phase NiO

phases. Table IV shows the crystal constants of the phases as determined by X-ray analysis. Tables V, VI, VII, and VIII summarize the X-ray diffraction spectra data for CoO, NiO, CoO:Fe_2O_3 and NiO:Fe_2O_3.

TABLE VII

X-RAY ANALYSIS, POINT A-3, 70% GLASS, 20% Co_3O_4, 10% Fe_2O_3

(Camera radius = 20.326 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face	a_0
1	2	4.906	0.12070	2.9485	110 (2)	8.3384
2	10	5.730	0.14094	2.5279	311	8.3840
3	2	6.893	0.16955	2.1032	100 (4)	8.4128
4	1	8.501	0.20911	1.7103	211 (2)	8.3788
5	5	9.019	0.22185	1.6137	111 (3)	8.3851
6	6	9.864	0.24263	1.4778	110 (4)	8.3598
7	1	11.046	0.27171	1.3228	310 (2)	8.3662
8	1	11.465	0.282021	1.2757	533	8.3614
9	1/2	12.134	0.29844	1.2072	111 (4)	8.3637
10	1/2	13.144	0.323217	1.1178	321 (2)	8.3648
11	1	13.503	0.33215	1.0889	553	8.3639
12	1/2	14.052	0.34565	1.0476	100 (8)	8.3808
13	Weak	14.958	0.36794	0.9870	110 (6)	8.3749
14	1/2	15.314	0.37670	0.9651	111 (5)	8.3580
15	Bad line	15.762				
16	Weak	16.910	0.39136	0.9308	431 (2)	8.3244
17	"	17.125	0.42124	0.8683	931	8.3233
18	"	17.449	0.429218	0.8531	211 (4)	8.3587
19	"	18.147	0.44638	0.8223	431 (2)	8.3453
20	"	18.490	0.45482	0.8081	951	8.3591

Mean of all lines, 8.3595
Phase, CoO:Fe_2O_3, a_0 8.36

TABLE VIII

X-RAY ANALYSIS OF GLASS CONTAINING 5% Ni_2O_3, 6% Fe_2O_3, GLASS IN IRON CRUCIBLE

(Camera radius = 11.280 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face	a_0
1	5	3.164	0.140248	2.539655	311	8.4230
2	4	3.820	0.169326	2.10656	400	8.4262
3	1	4.672	0.207092	1.72656	422	8.4584
4	2	5.008	0.221986	1.61237	333	8.3782
5	3	5.480	0.242908	1.47593	440	8.3491
6	1	6.340	0.281028	1.27998	533	8.3895
7	F	6.684	0.296277	1.21590	444	8.42399
8	1	7.494	0.332181	1.08862	553	8.3618
9	F	7.837	0.347385	1.04276	800	8.3420
10	1	8.472	0.375532	0.96792	555	8.3844
11	1	9.170	0.406472	0.89580	664	8.4034

Mean of all, 8.3949
Mean of 1, 2, 3, 6, 7, 10, 11, 8.4087
Mean of 4, 5, 8, 9, 8.3552
Phase Fe_3O_4 with some NiO:Fe_2O_3

The saturation limits of the three-component systems are shown in Fig. 1; composition limits are given in Table IX, while a comparison of phases found in melts of similar composition after heating in sillimanite and iron crucibles is given in Table X.

TABLE IX

COMPOSITION LIMITS OF NONMETALLIC PHASE IN SILLIMANITE

Phase Composition	System No. 1 Co_3O_4 (%)	System No. 1 Fe_2O_3 (%)	System No. 2 Ni_2O_3 (%)	System No. 2 Fe_2O_3 (%)	System No. 3 Co_3O_4 (%)	System No. 3 Ni_2O_3 (%)
Fe_3O_4	0.00	24.5 (A)*	0.00	24.5 (M)*	..	.....
Fe_2O_3	0.00	24.5 (A)	0.00	24.5 (M)	..	.....
	0.20	24.3 (B)	1.00	16.0 (N)	..	.....
CoO:Fe_2O_3	0.20	24.3 (B)	..	.....	..	.....
	23.30	6.8 (D)	..	.....	..	.....
NiO:Fe_2O_3	..	.....	1.00	16.0 (N)	..	.....
	..	.....	7.00	1.5 (P)	..	.....
CoO	18.50	7.4 (C)	..	.....	31.6	0.00 (W)*
	31.60	0.0 (E)	..	.....	11.6	3.50 (Y)
NiO	..	.....	6.00	5.0 (O)	20.0	0.75 (X)
	..	.....	9.00	0.0 (Q)	0.0	9.00 (Z)

* NOTE: Letters denote phase limits on diagram. See Fig. 1.

TABLE X

COMPARISON OF NONMETALLIC PHASES IN MELTS IN SILLIMANITE AND IRON CRUCIBLES

Composition Co_3O_4	Composition Fe_2O_3	System No. 1 Sillimanite	System No. 1 Iron
0.00	24.5	Fe_2O_3 and Fe_3O_4	Fe_2O_3 and Fe_3O_4
11.5	13.0	CoO:Fe_2O_3	CoO:Fe_2O_3
18.5	7.4	"	"
24.4	6.3	CoO	CoO
31.6	0.00	"	"

Ni_2O_3	Fe_2O_3	System No. 2 Sillimanite	System No. 2 Iron
0.00	24.5	Fe_2O_3 and Fe_3O_4	Fe_2O_3 and Fe_3O_4
6.00	5.00	NiO:Fe_2O_3	NiO:Fe_2O_3, Fe_3O_4
9.00	0.00	NiO	No nonmetallic phase

Co_3O_4	Ni_2O_3	System No. 3 Sillimanite	System No. 3 Iron
31.5	0.00	CoO	CoO
5.5	5.0	NiO	CoO
0.00	9.0	NiO	No nonmetallic phase

Table X indicates a tendency for enamels to lose their excess of nickel oxide or nickel-oxide compounds through reduction to metallic nickel. Cobalt oxide is reduced to the divalent oxide (CoO) in both metallic and nonmetallic crucibles. Note in system No. 3 how the nickel oxides disappear while the cobalt oxides remain in the glass.

The effect of heating (in metallic crucibles) upon melts containing Fe_2O_3 in excess is shown by Fig. 2. Three zones are visible in the photomicrograph: the first, adjacent to the steel, is evidently saturated with either Fe or FeO. There is no crystal phase in evidence. The second

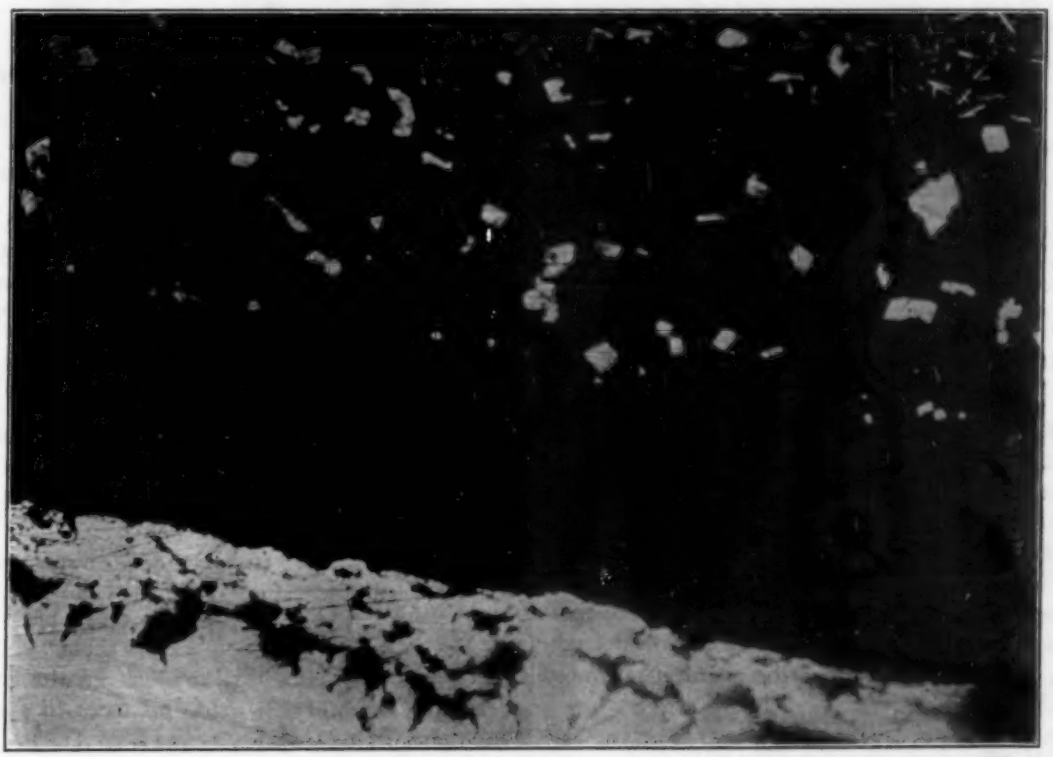

FIG. 2.—25% Fe_2O_3 enamel glass heated in iron crucible (400 ×).

shows the characteristic octahedrons of Fe_3O_4, while the third zone shows the plate-like crystals of Fe_2O_3. Evidently the degree of penetration of the reducing effect of the metal or of the oxidizing effect of the air is limited, even in melts heated to high temperatures for fairly long periods of time.

V. Metallic Crystal Phases

When the three-component systems were heated in iron crucibles four metallic crystal phases made their appearance in the melts. These were alpha-iron, nickel, alpha-cobalt, and beta-cobalt. Identification of metallic phases was made by X-ray analysis and was somewhat complicated by the fact that usually more than one phase was found to be present. The same phases were found in two-component systems.

TABLE XI

X-RAY IDENTIFICATION OF METALLIC PHASES

Phase	System	a_0 (found)	a_0 (given)†
Alpha-iron	Cubic-body centered	2.856–2.860	2.861
Nickel	Cubic-face centered	3.567	3.52–3.60[4]
Alpha-cobalt	Cubic-body centered	3.55	3.554
Beta-cobalt	Hexagonal	2.508 and 4.096	2.5 and 4.10[3]

† See R. W. G. Wyckoff, footnote, Table IV, p. 209.

TABLE XII

THREE-COMPONENT SYSTEMS—METALLIC AND NONMETALLIC PHASES IN IRON CRUCIBLES

Oxides (%)	Metallic phase	Nonmetallic phase
24.5 Fe_2O_3	None	Fe_2O_3, Fe_3O_4
8.0 Fe_2O_3, 17.3 Co_3O_4	αFe, αCo, βCo	CoO:Fe_2O_3
5.0 Fe_2O_3, 6.0 Ni_2O_3	Nickel*	NiO:Fe_2O_3, Fe_3O_4
5.5 Co_3O_4, 5.0 Ni_2O_3	αFe, Ni	CoO
31.6 Co_3O_4	αFe, αCo, βCo	None
9.0 Ni_2O_3	αFe, Ni	None

* Identified by qualitative analysis.

Metallic nickel was present in all cases in solid solution with iron. Ewald[4] reports the a_0 of nickel-iron solid solutions as varying from 3.52 to 3.60. The a_0 of metallic nickel found in the investigation was 3.56. Metallographic and X-ray investigations showed metal dendrites to be present in all enamels of each of the three-component systems which were heated in iron crucibles with the exception of the enamels saturated with Fe_2O_3 and containing no cobalt or nickel oxides and the 6% nickel-oxide and 5% iron-oxide enamels. In the latter case a bright metallic deposit was noticed on the surface of the crucible. Qualitative analysis revealed this to be nickel.

Tables XIII and XIV show the metallic and nonmetallic phases found to be present in the two-component systems. Figure 3 shows a typical metallic dendrite as found in the 10% Co_3O_4–glass.

TABLE XIII

SYSTEM Co_3O_4–GLASS: METALLIC AND NONMETALLIC PHASES IN IRON CRUCIBLE MELTS

Co_3O_4 (%)	Metallic phase	Nonmetallic phase
29.0	αFe, αCo, βCo	None
17.0	αFe, αCo βCo	None
10.0	αFe, αCo	
2.5	αFe, αCo	None
1.25*	αFe	None
0.00	None	None

TABLE XIV

SYSTEM Ni_2O_3–GLASS: METALLIC AND NONMETALLIC PHASES IN IRON CRUCIBLE MELTS

Ni_2O_3 (%)	Metallic phase	Nonmetallic phase
9.0	αFe, Ni	None
5.0	αFe, Ni	None
2.5*	αFe	None
0.00	None	None
Commercial enamel	αFe	None

* From Schwartzwalder: Heated one hour at 1600°F, allowed to soak 24 hours (see footnote 1, p. 208).

VI. Metallic Oxide Replacement in Enamel Glass

The effect of the various metallic oxides upon the mutual solubility of each other in enamel glasses is of considerable interest in the study of the mechanics of enamel adherence.

The maximum solubility of the three metallic oxides was found to be Co_3O_4 31.6%, Fe_2O_3 24.5%, and Ni_2O_3 9%. Because of its low solubility

TABLE XV

MAXIMUM AND MINIMUM METALLIC OXIDE REPLACEMENT RATIOS

Oxides	Maximum ratio	Minimum ratio
Co_3O_4–Fe_2O_3	1:1	2:1
Ni_2O_3–Fe_2O_3	1:8.5	1:1
Ni_2O_3–Co_3O_4	1:11	1:1

Ni_2O_3 was found to have a much greater effect upon the solubility of oxide mixtures in glasses than either Co_3O_4 or Fe_2O_3 (see Fig. 1).

Table XV gives the maximum and minimum

[3] A. W. Hull, "X-ray Crystal Analysis of Thirteen Common Metals," *Phys. Rev.*, **18**, p. 571 (1921).
[4] Ewald, Strukturbericht, p. 521 (1926).

oxide-replacement ratios. The only direct replacement of one oxide by another affecting more than a very small portion of the curves was found in system No. 1 where Co_3O_4 directly replaced Fe_2O_3 in amounts from 1 to 18.5%. In the systems involving nickel oxide, replacement was always greatest in parts of the system showing a low initial concentration of this oxide.

Summary and Conclusions

(1) Saturation boundaries of melts in sillimanite crucibles in the systems (1) Co_3O_4–Fe_2O_3–glass,

FIG. 3.—Metallic dendrite in 10% Co_3O_4 glass heated in iron crucible (400 ×).

TABLE XVI

X-RAY ANALYSIS OF METALLIC PHASES IN 29.0% Co_3O_4 ENAMEL GLASS

(Camera radius = 20.309 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face αFe	αCo	βCo	a_0
1	1	6.691	0.164733	2.1647			10·0	2.49
2	10	7.118	0.175247	2.0360	110	111	00·2	2.86–3.53–2.49
3	5	7.558	0.186090	1.9188			10·1	2.374
4	5	8.163	0.201073	1.7775		200		3.555
5	1	9.766	0.240441	1.4908			10·2	2.51
6	3	10.229	0.251840	1.4247	200			2.87
7	3	11.647	0.286751	1.2587		220	11·0	3.56–2.517
8	4	12.604	0.310313	1.1626	211		10·3	2.87–2.50
9	2	13.743	0.338356	1.0696		311	11·2	3.55–2.68
10	1	14.040	0.345668	1.0477			20·1	2.51
11	1	14.441	0.355541	1.0198	220	222	00·4	2.81–3.53–2.50
12	Weak	16.424	0.404363	0.9023	130			2.86
13	"	18.406	0.453160	0.8109		331		3.54
14	"	18.939	0.466283	0.7896		420		3.53
15	"	19.808	0.487678	0.7576	123	421		2.84–3.55
16	"	20.881	0.514059	0.7220		422		3.54

Mean $a_0\beta$Co " 2.508
Mean $c_0\beta$Co " 4.096

Mean αFe lines, 2.86
Mean αCo " 3.544
Phases: αFe, αCo, βCo

TABLE XVII

X-RAY ANALYSIS OF METALLIC PHASES IN 9% Ni_2O_3 ENAMEL GLASS

(Camera radius = 20.392 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face αFe	Ni	a_0
1	1	5.788	0.141918	2 5099		110	3.55
2	10	7.100	0.174088	2.0496	110	111	3.54–2.90
3	1	8.153	0.199907	1.7877		200	3.57
4	Weak	8.636	0.211750	1.6891			*
5	"	9.139	0.224083	1.5975			*
6	"	9.640	0.236367	1.51595			*
7	1	9.959	0.244189	1.46831		211	3.595
8	1	10.258	0.251520	1.42643	200		2.853
9	1	11.611	0.284695	1.26394		220	3.574
10	2	12 607	0.309116	1.16692	211		2.858
11	1	13.698	0.335867	1.07710		113	3.572
12	Weak	14.636	0.358866	1.01097	220	222	3.50–2.86
13	1	15.556	0.381424	0.95368			*
14	1	16.480	0.404080	0.89157	130	400	3.57–2.82
15	1	19.688	0.482738	0.76475	123		2.861

Mean of αFe lines, 2.858
Mean of Ni lines, 3.567
Phases: αFe, Ni

* Lines 4, 5, 6, and 13 may be in whole or in part NiO but are too weak for definite conclusions to be reached; intensities are off since stronger lines in the NiO spectrum are missing.

TABLE XVIII
X-RAY ANALYSIS OF METALLIC PHASES IN 1.25% Co_3O_4 GLASS*
(Camera radius = 20.266 cm.)

Line	Intensity	Length	θ (radians)	d/n	Face	a_0
1	9	7.151	0.176428	2.0226	110	2.8599
2	Weak	9.502	0.234432	1.5283	220	4.270
3	2	10.186	0.251308	1.4276	200	2.855
4	Weak	11.116	0.274252	1.31081	310	4.241
5	3	12.552	0.309681	1.1649	211	2.853
6	1	14.515	0.358112	1.0127	220	2.864
7	2	16.387	0.404298	0.90245	130	2.854
8	2	19.589	0.483297	0.7639	123	2.858
9	1	22.496	0.552822	0.6761	411	2.856
10	1	23.960	0.591138	0.6282	240	2.810
11	1	25.260	0.623211	0.6082	332	2.852
12	1	26.483	0.653385	0.5840	422	2.862
13	1	27.850	0.687111	0.5597	134	2.854

Mean of all but 2, 4, and 10, 2.857
Phase αFe

NOTE: Lines 2 and 4 may be CoO, FeO, or both. Since both oxides follow the same crystal habit (simple cubic), positive identification is impossible without more data.

* From Schwartzwalder: Heated one hour at 1600°F, allowed to soak 24 hours (see footnote 1, p. 208).

(2) Ni_2O_3–Fe_2O_3–glass, and (3) Co_3O_4–Ni_2O_3–glass were determined and plotted.

(2) Saturation phases in sillimanite crucibles along the boundaries were found to be for system No. 1: Fe_2O_3, Fe_3O_4, CoO:Fe_2O_3, and CoO; No. 2: Fe_2O_3, Fe_3O_4, NiO:Fe_2O_3, and NiO; and No. 3: CoO and NiO.

(3) Saturation phases in metallic (iron) crucibles were found to be for system No. 1: Fe_2O_3, Fe_3O_4, CoO:Fe_2O_3 and CoO plus αFe, βCo, and βCo; No. 2: Fe_2O_3, Fe_3O_4, NiO:Fe_2O_3, and NiO plus αFe and Ni; and No. 3: CoO, αFe, Ni, αCo, and βCo.

(4) In the two-component system, Co_3O_4–glass X-ray study of the metallic-dendrite phase showed the presence of both α and β cobalt along with αFe in glasses containing more than 10% Co_3O_4, and αCo and αFe in glasses containing from 1.25 to 10% Co_3O_4. Glasses containing 1.25% Co_3O_4 (or less) were found to contain only αFe.

(5) In the two-component system, Ni_2O_3–glass metallic dendrites in glasses containing more than 2.5% Ni_2O_3 were found to be composed of αFe and a solid solution of αFe and Ni. At 2.5% αFe alone was present.

(6) Commercial glasses heated in iron crucibles were found to contain only αFe.

(7) Experiments with the three-component systems showed the effect of time and temperature upon the viscosity of enamel glasses. It is pointed out that decreased viscosity due to these factors was designed to allow the systems to approach as nearly a condition of equilibrium as possible. For these reasons the state of the system in the iron cups more closely approaches equilibrium than is the case in commercial practice.

(8) Mutual replacement of Co_3O_4, Ni_2O_3, and Fe_2O_3 in the three-component systems was determined. Co_3O_4 and Fe_2O_3 were found to replace each other directly in the glasses while Ni_2O_3 replaced the other oxides in amounts up to 11%.

Acknowledgment The writers are glad to acknowledge the helpful advice and coöperation of W. J. McCaughey in making the X-ray portion of the investigation possible, and of J. O. Lord on the metallographic work. This is a contribution from the Engineering Experiment Station and Ceramic Department of the Ohio State University.

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MECHANICS OF ENAMEL ADHERENCE. X

The "Iron Oxide Layer" in Sheet-Steel Ground Coats*

By R. M. King

ABSTRACT

The formation and significance of the so-called "iron oxide layer" have have studied experimentally and are discussed here.

I. Introduction

Many theories have been advanced to explain the special adhering qualities of ground coats containing cobalt and nickel oxides when applied and fired onto sheet steel. The theories most frequently mentioned assume the formation of an intermediate phase at the enamel-iron interface and that this phase acts as an intervening bond which holds the enamel to the steel. Some advocates of such theories contend that this intermediate phase is a metal-cobalt or nickel,[1] while others maintain that it is iron oxide.[2]

The supporting arguments for a metallic phase are as follows: (1) Since iron is higher than cobalt in the electromotive-force series, the iron from the base will go into solution and the cobalt will precipitate. (2) The deposited cobalt alloys with the iron and bonds the enamel to the iron.

The arguments for the formation of the iron-oxide layer are as follows: (1) Infiltering air, soda deposited on steel by neutralizing solution, and various constituents of the enamel oxidize the iron to form an iron-oxide layer. (2) This layer adheres to the steel on the one hand and to the enamel on the other and thus acts as a bonding or adhering agent. (3) The special rôle of cobalt and nickel oxides is to partially saturate the enamel, thus reduce its iron-oxide dissolving power, and hence prevent complete solution of the iron-oxide layer. (4) The lack of adherence of the cobalt-oxide free enamel is due to the complete solution of iron oxide by the enamel, thus bringing it in direct contact with the steel with which it is not supposed to adhere.

It is worth noting here that no one has actually identified any iron oxide in a cobalt- or nickel-oxide ground coat. It has been assumed that the black layer often observed on the steel side of a ground-coat chip is iron oxide. Meures[2g] has identified various forms of iron oxide in an enamel free of cobalt and nickel oxides.

In this investigation on "The Mechanics of Enamel Adherence,"[3] the following points have been established:

(1) When a cobalt or nickel oxide-bearing ground coat is fired on sheet steel in the usual manner a metallic phase is precipitated at the steel-enamel interface. (2) In ground coats of usual cobalt- and nickel-oxide content this metallic phase is alpha-iron. At higher concentrations of the oxides, α and β cobalt or nickel may also precipitate. (3) When manganese oxide only is present or when no adherence-promoting oxides are present, no metallic phase is precipitated.

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* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received February 14, 1934.

[1](*a*) R. Vondracek, "Ausgewählte Kapitel aus der Eisenemailleritechnik," *Sprechsaal*, **42** [14], 201–202 (1909).

(*b*) M. Mayer and B. Havas, "Über die Bedeutung der Grundemails," *ibid.*, **43** [49], 727–28 (1910).

(*c*) C. Tostmann, "Die Bedeutung der Grundemail," *Keram. Rund.*, **19** [5], 65, 107 (1911).

[2] (*a*) Menzel, "Die Bedeutung des Kobaltoxyds in Grundemail bei emailliertem Blechgeschirr," *ibid.*, **22** [50], 423–24; [52], 432–33 (1914); **34** [27], 417–18; [28], 462–63 (1926).

(*b*) L. Vielhaber, "Das Verhalten der Metalloxyde in Grundemails auf Blech," *ibid.*, **33** [4], 53–55 (1925).

(*c*) P. Eyer, "Kobaltoxyde und Grundemail in Spiegel der Literatur," *ibid.*, **33** [49], 843–44 (1925).

(*d*) R. D. Cooke, "The Effect of Furnace Atmosphere on Firing of Enamel," *Jour. Amer. Ceram. Soc.*, **7** [4], 277–81 (1924).

(*e*) H. Eisenlohr, "Haftung von hellem Grund auf Eisenblech," *Emailletechnische Monats-Blätter*, **9** [1], 1–6 (1933); "Das Haftinterval für Grundemails," *ibid.*, **9** [2], 11–12 (1933).

(*f*) K. Beyerlein, "Beitrag zur Wirkung der Haftoxyd in Grundemails," *Keram. Rund.*, **40** [16], 205–208 (1932); *ibid.*, **40** [17], 221–22 (1932).

(*g*) K. Meures and E. Zschimmer, "Beiträge zur Erklärung des Haftens von Emaille und Eisenblech," *Sprechsaal*, **65** [4], 63–64 (1932); [5], 83–85; [7], 119–21; [8], 138–39 (1932).

[3] (*a*) G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence, V. A Study of Enamel-Metal Contact Zones by Chemical Methods," *Jour. Amer. Ceram. Soc.*, **15** [9], 480–83 (1932).

Other papers in this series are not specifically referred to but are listed here for the reader:

(*b*) Karl Schwartzwalder and R. M. King, "Mechanics of Enamel Adherence, VI. A Petrographic, Metallographic, and X-ray Study of Enamel-Metal Contact Zones," *ibid.*, pp. 483–86 (1932).

(*c*) G. H. Spencer-Strong, J. O. Lord, and R. M. King, "Mechanics of Enamel Adherence, VII. Further Studies of Enamel-Metal Contact Zones by Microscopic and Metallographic Methods," *ibid.*, pp. 486–90 (1932).

(*d*) R. M. King, "Mechanics of Enamel Adherence, VIII," *ibid.*, **16** [5], 232–38 (1933).

(4) The metals are precipitated in the dendritic form. (5) When a cobalt- or nickel-oxide ground coat is fired *in vacuo*, few or no dendrites are visible at high magnification (500 ×). (6) When fired *in vacuo* these ground coats will not adhere to steel but flake off without bending or impact, exposing a bright steel surface. (7) X-ray analysis has not revealed the presence of iron oxide at the interface when enamel is normally fired or when fused in an iron crucible saturated with iron and cobalt oxides and held in the molten condition at 2500°F for 30 minutes. However the spinels of iron oxide-cobalt oxide, iron oxide-nickel oxide, or the cobalt and nickel oxides may be present. (8) When ground coats saturated with cobalt, nickel, and iron oxides are heated in a sillimanite crucible, the individual oxides or mixtures or compounds of these oxides, depending upon the composition of systems, are precipitated. (9) The addition of up to 18% cobalt oxide does not materially lower the solubility of the iron oxide in the enamel, but the addition of even small percentages of nickel oxide lowers the solubility of iron oxide markedly. More cautiously speaking, cobalt oxide plus iron oxide at saturation composition will total about the same amount as the iron oxide at saturation composition, but when nickel oxide is added the total of the two oxides is less than the iron-oxide composition. (10) A ground-coat base will dissolve more cobalt oxide than iron oxide. (11) The iron content in a fired ground coat increases with an increase in cobalt-oxide content of the enamel and amounts to about 10% (14.3% Fe_2O_3) when enamel contains 2.2% CoO. Such an enamel should contain 28% Fe_2O_3 when saturated. (12) When fused in an iron crucible at 2500°F for 30 minutes, a cobalt-oxide ground coat adheres to the crucible on cooling.

It has been pointed out that when cobalt- and nickel-oxide ground coats were fired *in vacuo* the enamel chipped cleanly from the steel and that few or no metallic dendrites were formed. It was suggested to the author that this was probably due to the absence of air which prevented the formation of the iron-oxide layer which is supposed to promote adherence. In order to make a more careful study of the claims regarding the possible formation and function of iron oxide, the following experiments were performed.

II. Experimental

In many of the following experiments the term "procedure 8" will be used and refers to procedure 8 in No. VIII of this series of papers.[3d] It consists of firing *in vacuo* to completion and reëstablishing atmospheric conditions 20 seconds before the furnace is removed.

(1) Experiment No. 1 Unpickled steel test pieces were held in a furnace at 1600°F for 20, 30, and 60 seconds, thus forming brown, blue, and black coatings, respectively. On cooling, a commercial ground coat was applied, dried, and fired by procedure 8. Within 24 hours the enamel chipped directly from the steel in the case of the "brown" and "blue" steels, but the enamel did not chip from the "black" steel and even withstood application of a cover coat. Photomicrographs of polished sections from the "blue" and "black" steels showed incipient formation of dendrites in the former and marked formation in the latter (Fig. 1). There was also apparent in the latter case an interfacial layer which might be iron oxide, although no discrete crystals were visible at high magnification.

FIG. 1.—Preoxidized steel plus ground coat fired *in vacuo*.

(2) Experiment No. 2 Thin layers of various oxides were "painted" on pickled steel pieces. After drying, a commercial ground coat was applied by dipping. The oxides used were commercial cobalt oxide, red iron oxide (Fe_2O_3), magnetic iron oxide (Fe_3O_4), and manganese dioxide (MnO_2). After the enamel was applied and dried, the pieces were fired by procedure 8. Pieces coated with cobalt oxide showed no chipping at the end of six months. When forcibly bent the enamel cracked off as does a normally fired cobalt-oxide enamel. Photomicrographs of polished sections of the cobalt-oxide coated piece showed copious dendrite formation. The iron-oxide coated pieces showed deep fishscaling or slight chipping. Pieces coated with Fe_2O_3 showed few or no dendrites, while there were some dendrites present in those coated with Fe_3O_4. The pieces coated with lead and manganese oxides showed deep

fishscaling. Photomicrographs were made from a manganese-oxide piece and showed some dendrite formation.

(3) Experiment No. 3 The above oxides, nickel oxide, and oxide scale from heated sheet, were mixed singly with a commercial ground coat before applying by dipping and were fired by procedure 8. The results were practically the same as above. The nickel-oxide piece showed slight surface fishscaling. Oxide scale showed deep fishscaling. No photomicrographs were made.

(4) Experiment No. 4 A ground-coat base, *i.e.*, a ground coat minus cobalt and nickel oxides, was applied to several steel pieces fired *in vacuo* by procedure 8. When fired these enamels were transparent and bubble-free. Powdered ground-coat frit, cobalt oxide, red iron oxide, and magnetic iron oxide

FIG. 2.—Co_3O_4 fired on prefired base ground coat.

were sprinkled on and the pieces fired to 1650°F four minutes in air. When oxides were used the enamel chipped off in the areas where no oxide was fused into the enamel. Photomicrographs of a cobalt-oxide trial showed marked solution of the iron (see Fig. 2). In the case of trials in which regular ground-coat frit was used, the enamel separated directly from the steel within a few hours.

(5) Experiment No. 5 A similar series was prepared in which the materials mentioned were sprinkled on the base ground coat after firing in air and then refired at about 1650°F for 4 minutes. Results similar to those of Experiment No. 6 were obtained in the case of the oxides and in this case the regular frit caused adherence sufficient to prevent chipping but not enough to enable a polished section to be made.

(6) Experiment No. 6 A third series of analogous nature was prepared by firing a commercial ground coat *in vacuo* by procedure 8. The above oxides, flint, borax, and regular frit were sifted onto separate trials and fired in the same manner. The pieces with oxides showed no chipping, those with frit showed bad chipping, and those with flint and borax showed slight chipping.

In considering the above experiments, the following facts stand out: (1) Oxygen must be available to the ground coats containing CoO and NiO during the firing period. (2) Where good adherence was obtained, marked formation of metallic dendrites was also noted. There were two rather indefinite cases in which iron oxide could be considered to function as a bond: (*a*) when the commercial ground coat was fired *in vacuo* on steel covered by black "iron oxide," obtained by heating, and (*b*) when iron oxides were sifted onto the oxide-free glass, which had been fired *in vacuo* and then fired in air. In case (*a*) a distinct layer was visible, but a crystal formation could not be identified under high magnification; case (*b*) was difficult to interpret in view of the fact that it was necessary to fire at high temperatures to get penetration of the oxide which at the same time brought about a condition of overfiring.

In view of the fact that the above experiments indicated that there was a definite association of adherence, dendrite formation, and oxygen availability in firing cobalt- and nickel-oxide ground coats, the following experiments were performed to determine the source of the oxygen in normal firing procedure.

(7) Experiment No. 7 Some ground-coated test pieces were heated in air in a furnace at 1600°F at various time intervals up to the time necessary to fuse the enamel. This required about 30 seconds. When the enamel was broken or brushed off, the metal appeared dark, presumably due to the formation of iron oxide. This confirmed Cooke's[24] observation. However, it should be pointed out here that within 30 seconds the enamel had fused completely enough that no holes were visible under the microscope. This raised the question as to whether there was sufficient penetration of air through channels in the enamel, before fusing, to bring about satisfactory adherence.

(8) Experiment No. 8 In order to answer this question some regularly ground-coated pieces were preheated in air in a furnace at 1600°F at various time intervals. These pieces were cooled and fired by procedure 8. If preheated 25 seconds, *i.e.*, just below the sintering point, most of the pieces showed deep fishscaling. If preheated 30 seconds, the minority of the trials showed deep fishscaling. If preheated to complete fusion, 35 to 45 seconds, the enamel did not chip; in fact a cover coat was applied without chipping. The results leave little doubt as to the fact that air penetration prior to fusion contributes to adherence.

(9) Experiment No. 9 A number of test pieces was fired in the vacuum apparatus at various times and temperatures under atmospheric conditions to determine the conditions for completely fusing the enamel. Thin pieces were broken from the steel and examined under the microscope. There were no microscopically observable holes through which the air might penetrate when the pieces were fired to 1425°F for $2^3/_4$ minutes.

(10) Experiment No. 10 A series of firing was performed by firing *in vacuo* up to various temperatures and then completing the firing in air.

It was found that if the enamel were fired to 1470°F *in vacuo* three minutes, chipping sometimes occurred and sometimes did not occur. However, if fired *in vacuo* above this temperature chipping always occurred and in no case did it occur when fired below this temperature, *e.g.*, 1425°F *in vacuo*, before completing the firing in air. Dendrite formation was observed from photomicrographs of a piece fired at 1425°F.

In view of the fact that the enamel was well fused by the time it reached a temperature of 1425°F, penetration of air through pores or channels in the unfused enamel is precluded by the above firing procedures. But since it has been strongly indicated that oxygen is necessary to bring about adherence, and since the exclusion of air until the enamel is fused does not prevent adherence or dendrite formation, some contributing source of oxygen in addition to air penetration through the unfused enamel must be sought. Results of experiment No. 10 suggest that one source of oxygen may be the gases known to be dissolved or dispersed in the enamel.

(11) Experiment No. 11 Several ground-coated pieces were fired *in vacuo* to about 1525°F in four minutes. Atmospheric pressure was then reëstablished and firing continued for about two minutes when a temperature of about 1625°F was reached. The enamel did not chip off. This indicates that oxygen from air in contact with the enamel after fusing is sufficient to bring about the necessary adherence, if given sufficient heat treatment. Photomicrographs showed the presence of dendrites. This is a strong indication that oxygen in air contributes to adherence and dendrite formation even after the enamel is fused.

(12) Experiment No. 12 It was noted that the enamel pieces which chipped from the steel, when firing was carried out by procedure 8, consisted, as do such pieces from the normally fired ground coat, of two distinct layers. The layer which had been in contact with the steel was black. Under the microscope these pieces of enamel appeared to contain a formation of red crystals. A quantity of this enamel was powdered and a separation made in bromoform. An X-ray examination of the heavier fraction and magnetite and FeO were found. See Table I.

TABLE I

X-RAY DATA OF INTERFACIAL LAYER OF VACUUM-FIRED ENAMEL

$2R$ = 22.600

Line	Int.	Line	Sinθ	d/n	Face	a_0
1	1	2.673	0.1180021	3.0084	220	8.5077
2	5	3.667	0.1867567	2.17058	400	8.6823
3	1	4.733	0.2078957	1.70758	422	8.36543
4	2	5.019	0.220258	1.60809	333	8.356
5	3	5.336	0.233923	1.51759	220	4.291 (FeO)
6	3	5.479	0.2400634	1.47878	440	8.3653
7	1	6.304	0.2753324	1.2870	541	8.4066
8	1	6.564	0.2863734	1.23964	631	8.40761
9	1	7.464	0.3240907	1.095372	730	8.3421
10	1	7.815	0.338949	1.04736	800	8.37888
11	1	8.319	0.3598405	0.98655	660	8.37117
12	2	8.560	0.369767	0.96006	662	8.3696
13	1	8.771	0.3784298	0.93809	810	8.39055
14	1	9.415	0.4046426	0.87732	831	8.3691
15	1	9.670	0.41483 2	0.85576	844	8.3847
16	F	11.133	0.4729283	0.75064	865	8.3921

Mean of all, 8.39426
Mean of all but 1 and 2, 8.37169
Known a_0 for magnetite–Fe_3O_4, 8.370*
* R. W. G. Wyckoff, The Structure of Crystals, 2nd ed., The Chemical Catalog Co.

This brings about an anomalous situation: Iron is obtained in its lowest stage of oxidation under oxidizing conditions and in higher stages of oxidation under presumably reducing condi-

tions. Iron is also obtained under conditions of good adherence and iron oxide under conditions of nonadherence.

III. Summary and Conclusions

During the firing of cobalt- and nickel-oxide ground coats, oxygen must be available in order to procure good adherence and dendrite formation. The source of oxygen may be air or an oxide that will liberate oxygen.

In normal firing procedures air penetration before and after fusing contribute to adherence and dendrite formation. It is probable that oxygen dissolved or dispersed in the enamel also contributes to these phenomena.

X-ray analysis of the interfacial layer of enamel ground coats fired *in vacuo* (procedure 8) reveal the presence of magnetite and FeO.

Previous papers have reported that no form of iron oxide has been detected in cobalt- and nickel-oxide ground coats fired under normal procedures or other procedures conducive to iron-oxide formation. Hence it is concluded (1) that the good adherence of ground coats containing cobalt and nickel oxides is closely associated with the formation of metal dendrites, which are of alpha iron in the case of commercial ground coats normally fired; and (2) that this adherence is not associated with iron oxide because (*a*) no form of iron oxide has been found in enamels fired under normal conditions, (*b*) solubility tests indicate that if formed the iron oxide would be dissolved and become a part of the glass, and (*c*) iron oxide has been found at the interface when cobalt- and nickel-oxide ground coats do not adhere.

Acknowledgment This paper is a contribution to a series on the fundamental study of enamels which is being supported in part by the Engineering Experiment Station of the Ohio State University. Grateful acknowledgment is made to George H. Spencer-Strong who made the X-ray analysis and James A. Eagelson who did the metallographic work.

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SALT-GLAZING AT CONE O2 BY SLIP APPLICATION*

By Marion L. Fosdick

I. Introduction

(1) Objects The object of this experiment was to develop the following results: (*a*) a self-glazing body, practicable for teachers, craftsmen, and individual producers; (*b*) a product which could be fired at faience temperatures in an oxidizing atmosphere in open or muffle kilns and with other ware; and (*c*) a palette of colored clays suited to the process.

In the first tests pieces were cast in molds and slip was applied with a brush. After successful results had been arrived at, the bodies were thrown on the wheel without difficulty.

II. Body Requirement

It was found that the density of the body should, on the one hand, be sufficient to hold the salt on the surface of the ware and, on the other, to allow the sodium oxide from the salt to form a glaze with silica from the body mass at the temperature at which the salt would vaporize.

After numerous experiments good red and white bodies were made as follows:

Body A (red)

Enfield R clay	83.4
Buckingham feldspar	8.3
Flint	8.3
	100.0

Body B (white)

Sagger clay (H1)	70.9
Buckingham feldspar	7.1
Monmouth clay	17.7
Flint	4.3
	100.0

As the Monmouth clay is in extensive use in schools and studios it was adjusted as to density by the use of colemanite. Several experiments resulted in the following body:

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Art Division). Received February 14, 1934.

Body C	
Monmouth clay	90.90
Colemanite	1.84
Flint	7.26
	100.00

III. Preparation of the Bodies

The bodies were prepared by sifting the dry mixed clay through sieves of 60-, 80-, and 100-mesh, respectively. The slips were mixed by hand and lawned through 100-mesh. Upon firing, the bodies of 60-mesh were rough and undeveloped. Those of 80-mesh were just as good as those of 100-mesh, so that 80-mesh was adopted for all the tests.

A series of tests was also made with body A, using from 10 to 40% of 60-mesh salt. The results were not so good as when no salt was used.

Each of the bodies was sifted through 100-mesh, mixed dry with 40% of 60-mesh salt, and made into slip. After experimentation the following conclusions were reached:

When the slip was laid on dry clay so much cracking ensued that the idea was abandoned.

There was no cracking when the body was leather-hard.

The slip had to be applied both inside and outside the piece (an application on the outside only did not develop a glaze).

The laying of a thick slip both inside and outside a leather-hard piece naturally tended to make the clay too wet to stand up; this was corrected by allowing half an hour to pass between the two applications.

Quick drying in a very hot room prevented the development of the glaze; the salt was brought to the surface and crystallized. Slow drying was then resorted to, but the wicking out of the salt was unequal, causing dry patches. It was then found that if the pieces were inverted for a definite period and then reverted while being kept moist the glaze would develop evenly.

The inversion and reversion could be avoided by the addition of 3% of dry dextrine to the body. This addition, however, made casting so slow as to be impracticable. It was especially practicable for ware made on the wheel.

IV. Colors Used

The following colored bodies were successful when used as slips:

Blue		Dark Blue	
Body B	96	Body B	94
Cobalt Carbonate	4	Cobalt Carbonate	6
Black		**Light red**	
Body A	97	Body B	90
Cobalt Carbonate	3	Enfield R	10

V. The Firing

It was found that lead glazes could not be fired at the same time as the salt glaze. The passage of air currents through the muffle caused dry patches to appear on the lead-glazed pieces and some of these were practically stripped of glaze. Colemanite and soda glazes suffered no injury even when placed in close proximity to the salt-glazed ware. Further tests may simplify the preparation of the bodies which, owing to the necessity of sifting the clays, is at present rather complicated. The process, however, offers an interesting and economical treatment of a pottery surface and one which has possibilities of beauty in design.

Acknowledgment The experiments presented here were suggested by a paper, read at the Annual Meeting of the American Ceramic Society in 1930. by J. Otis Everhart to whom acknowledgments are made.

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CERAMIC ABSTRACTS[1]

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Abrasives

Behavior of emeries in the Samos deposits. J. de Lapparent. *Compt. rend.*, **198** [8], 760–61 (1934).—Further investigation of the chemical composition and behavior of the emery deposits in the Greek Archipelagos confirms the view previously expressed that they originated in old bauxite deposits which have been transformed by climate and geological conditions. See also *Ceram. Abs.*, **13** [6], 153 (1934). M.H.

Grinding aids in making motors. Edwin Bremer. *Abrasive Ind.*, **15** [5], 10–11 (1934).—B. describes grinding operations used by the Master Electric Co. to insure accuracy of motor parts. Illustrated. A.J.M.

Polishing with aluminum oxide abrasives. A. A. Klein. *Metal Cleaning & Finishing*, **6** [4], 193–95 (1934).—The essential qualities of manufactured aluminum oxide abrasives for metal polishing are discussed. E.J.V.

Reducing tooling cost by grinding. H. J. Chamberland. *Abrasive Ind.*, **15** [5], 12–13 (1934).—C. describes how worn and discarded tools were reclaimed through grinding at one-fourth the cost of new ones. Specific instructions for regrinding mandrels and a chart showing how they should taper are given. Illustrated. A.J.M.

Speeding milling cutter production. Fred B. Jacobs. *Abrasive Ind.*, **15** [5], 14–15 (1934).—J. describes and gives drawings of several special inexpensive fixtures which reduce labor costs and increase accuracy in finishing milling cutters. A.J.M.

Wheel wear in cylindrical grinding. R. Woxén. *Ingeniørsvetenskapsakademien, Handlingar*, No. 124; abstracted in *Mech. World*, **95** [2466], 326 (1934).—An investigation of factors affecting wheel wear in external cylindrical grinding by the transverse method is reported. The experimental apparatus is described and factors of importance in the wear of grinding wheels are discussed. Specific wear is defined as the ratio S/M, where S is volume removed from the grinding wheel when the volume, M, is ground from the piece of work. It is concluded that specific wear increases and the wearing time decreases with (1) increase in the ratio between the surface speeds of the work and the wheel, (2) increase in chip thickness, and (3) increase in the specific volume of material. On analyzing the variables in cylindrical grinding by the transverse method, it is concluded that by increasing the wheel speed and employing suitable machines and wheels the volumes of material removed per unit of wheel width may be increased by at least 30% over those which are now usual without incurring excessive wear. E.J.V.

PATENTS

Abrasive and holder therefor. W. G. Dunn. U. S. 1,955,848, April 24, 1934. An abrasive of relatively thin, stiff, flexible material and a holder therefor having lips on the ends thereof for receiving the ends of the abrasive.

Abrasive stone holder. F. J. Jeschke (Micromatic Hone Corp.). U. S. 19,149 (reissue), April 24, 1934.

Apparatus for lapping or grinding. H. J. Wills (Carborundum Co.). U. S. 1,957,569, May 8, 1934.

Cam shaft lapping machine. H. J. Wills (Carborundum Co.). U. S. 1,957,568, May 8, 1934.

Cylinder grinding tool adjusting mechanism. H. W. Zimmerman (Automotive Maintenance Machinery Co.). U. S. 1,957,485, May 8, 1934.

Fixture. W. D. Schmidt (Heald Machine Co.). U. S. 1,958,021, May 8, 1934.

Gear testing and lapping machine. O. G. Simmons (National Tool Co.). U. S. 1,958,550, May 15, 1934.

Grinding machine. G. A. De Vlieg. U. S. 1,956,983, May 1, 1934. Frank Chateauneup. U. S. 1,957,879, May 8, 1934. H. W. Lanyon (Safety Grinding Wheel & Machine Co.). U. S. 1,958,709, May 15, 1934. Everard Stubbs (Norton Co.). U. S. 1,958,551, May 15, 1934.

Grinding machinery. L. R. Heim (Heald Machine Co.). U. S. 1,958,001, May 8, 1934.

Preformed abrasives and process of producing. E. S. Merriam. U. S. 1,956,905, May 1, 1934. A preformed abrasive article comprises a skeleton-like structure of aluminum oxide formed *in situ* about a softer, less dense medium.

Swing frame grinding machine. H. W. Dunbar (Norton Co.). U. S. 1,958,534, May 15, 1934.

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Tap grinder. C. R. BURT AND F. O. HOAGLAND (Pratt & Whitney Co.). U. S. 1,957,317, May 1, 1934.

Thread grinding machine. O. E. KOEHLER (Greenfield Tap & Die Corp.). U. S. 1,958,105, May 8, 1934.

Universal grinder. H. C. WOODSMALL (Mary A. Woodsmall). U. S. 1,958,734, May 15, 1934.

Valve grinder. ELMER RYDER. U. S. 1,958,498, May 15, 1934.

Apparatus for grinding and/or polishing glass, marble, etc. FORGES ET ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Brit. 408,775, April 25, 1934.

Grinding of rotating eccentric knives. W. E. MOLINS. Brit. 409,086, May 2, 1934.

Machines for grinding pins, rollers, tubes, etc. H. A. DUDGEON. Brit. 408,285, April 18, 1934.

Manufacture of abrasive articles. CARBORUNDUM CO., LTD. Brit. 408,971, May 2, 1934.

Art and Archeology

Ancient pottery of many lands, a résumé. I. LAURA B. CAMPBELL. *Ceram. Ind.*, **22** [5], 251–55 (1934).—The Egyptians were skilled in making pottery as early as 4400 B.C., being distinguished for their production of colored enamels and glazes which were varied and of great beauty and brilliance. They experimented successfully with metallic oxides and the chemical changes produced by heat, obtaining many shades of blues and greens in endless tints, purple, violet, yellow, red, and black. Some of their products are described. The Egyptian influence on the pottery of the nations with which Egypt was associated is clearly traceable. Assyrian and Babylonian pottery shows the Egyptian influence in the technical methods and the use of enameled pigments. Grecian pottery, like Grecian architecture and sculpture, is characterized by an individuality that expresses a beauty and symmetry that no other nation has ever attained. The types of decoration on Grecian pottery are described. Illustrated. E.J.V.

Archeological reconnaissances in southern Persia. AUREL STEIN. *Geographical Jour.*, **83**, 119–34 (1934).—The Harvard-British Museum expedition of 1932–33, of which S. was leader, is described and illustrated. H.H.S.

Ceramics of the stone age. CARL RANCKE. *Keram. Rund.*, **42** [3], 27–30; [4], 41–44 (1934).—An index of literature is given. Illustrated. M.V.K.

Color machine detects minute changes in shades. C. EARL HAYS. *Ceram. Ind.*, **22** [5], 263 (1934).—The Telecolor is a small boxlike color-matching device using photoelectric cells and includes an instrument with a graduated scale. The amount of energy emitted from the photo-cell is directly proportional to the amount of light directed on it, and any variation in color causes a difference in light reflection; minute color or shade changes can be readily detected. E.J.V.

Complementary color relations. E. GENBERG. *Proc. Phys. Soc.*, **45** [6], 836–40 (1933); abstracted in *Physik. Ber.*, **15** [4], 281 (1934). M.H.

Early Staffordshire pottery. G. J. V. BEMROSE. *Pottery Gaz.*, **59** [683], 597–601 (1934).—Pottery making in England dates back to pre-Roman times. The Roman influence brought about slip decorated pieces molded in relief. After a period of ceramic darkness following the withdrawal of the Roman armies there was a slow rebirth of pottery making in about the 14th Century. The centralization of pottery making in the potteries area was originally due to the geological feature of the northern part of the county, and later to the genius of Josiah Wedgwood. In the early part of the 17th Century a dull, brownish-red unglazed earthenware, usually thrown into the shape of long, cylindrical butter pots, and small vessels of cup-like form with a lustrous black-lead glaze were being produced. With the advent of slip-decorated ware began the definite potter. Various centers of production began to manufacture different types of ware and each had its own particular worker. The types of ware are described. Illustrated. E.J.V.

Experiments with cone 4a earthenware glazes. ANON. *Keram. Rund.*, **40** [45], 586–89 (1932).—Results of experiments show that with an increased B_2O_3 content the liquefaction and luster of fritted glazes generally increase. With respect to these properties, they surpass the corresponding raw glazes without B_2O_3. However, they are less resistant to the formation of hair cracks than raw glazes when employed on bodies having an absorption of water from 7 to 9%. M.V.K.

Grecian and Roman stucco, mortar, and glass. WILLIAM FOSTER. *Jour. Chem. Ed.*, **11** [4], 223–25 (1934).—Descriptions and analyses are given of specimens of Grecian and Roman stucco, mortar, and glass found during the American excavations at Corinth and Athens. Their comparison with modern materials is given. A.K.

Leadless glazes for the domestic pottery industry. L. I. SIVOPLYAS. *Ukrain. Chem. Jour.*, **8** [1], 104–109 (1933).—The ingredients for glaze manufacture were put through a 10,000-mesh/cm.² sieve. Neither the chemical compositions of these ingredients nor the compositions of the bodies to which the glazes were applied are indicated.

Batch Composition of Glaze No. 1
(fritted at 1100°C; applied to body A)

	Grams
Faience	1000
Quartz	200
Kaolin	3
Borax	800
Boric acid	70
Soda ash	90

Batch Composition of Nonfritted Glazes Nos. 2–7
(applied to body B)

	Parts
Easy melting clay	360
Quartz	120
Chalk	52
Soda ash	360
Ores of Fe, Cu, or Mn	30–90

Batch Composition of Nonfritted Glaze No. 11
(applied to water pipes)

	Grams
Easy melting clay	25
Quartz	4
Chalk	2
Soda ash	25
Iron ore	6

Batch Compositions of Nonfritted Glazes Nos. 19 and 20
(applied to body C)

Glaze No. 19	Parts	Glaze No. 20	Parts
Clay	60	Clay	50
Quartz	3	Quartz sand	10
Chalk	3	Chalk	5
Soda ash	50	Feldspar	5
		Soda ash	50

Glaze No. 21	Parts	Glaze No. 22	Parts
Clay	60	Clay	60
Quartz sand	10	Quartz sand	15
Chalk	5	Chalk	5
Feldspar	5	Feldspar	10
Soda ash	50	Soda ash	50

Batch Compositions of Fritted Glazes Nos. 24 and 26 (applied to body D)

Glaze No. 24	Parts	Glaze No. 26	Parts
Clay	60	Clay	60
Quartz sand	37	Quartz sand	40
Chalk	13	Chalk	13
Feldspar	15	Feldspar	15
Soda ash	50	Soda ash	50
Glass	20	Glass	20

The glazes are not inferior in quality to the lead glazes. They were used for domestic pottery manufacture and gave satisfactory results. S.I.P.

Metropolitan Museum of Art adds notable Wedgwood ware to its collection. C. L. AVERY. *Ceram. Age*, **22** [6], 173 (1933).—Illustrated. F.G.H.

Modern Danish ceramic ware. M. BODELSEN. *Danish Foreign Office Jour. Commercial Rev.*, **13,** 180–84 (1933).—The artwork of Kähler, Nielsen, Hansen-Jacobsen, Carl Halier, Nordström, Kyhn, Gauguin, and Salto is reviewed and illustrated. H.H.S.

New discoveries in the Agora of Athens. T. L. SHEAR. *Discovery*, **15,** 35–38 (1934).—The second season's work in the Agora is described and illustrated. A wealth of vases of all periods was found. H.H.S.

Old English glass. No. 51. FRANCIS BUCKLEY. *Glass*, **11** [4], 144–45 (1934).—A discussion of "glass pictures" is given. Illustrated. For No. 50 see *Ceram. Abs.*, **13** [6], 147 (1934). A.J.M.

Vitrifiable colors for decorating glassware. W. E. DOUGHERTY. *Jour. Amer. Ceram. Soc.*, **17** [6], 178–82 (1934).

BOOK

Campana Fragments in Florence. J. D. BEAZLEY. 35 pp., 20 plates. Oxford Univ. Press, 1934. Price 15s. Reviewed in *Times Lit. Supp.*, **33,** 77 (1934).—With considerable ingenuity, employing translucencies and other devices, B. has reconstructed the whole vases from the fragments in the Florence Museum. H.H.S.

PATENTS

Colorable ceramic composition and process for utilizing. A. E. BAGGS AND EDGAR LITTLEFIELD. U. S. 1,959,149, May 15, 1934. The method of coloring the surfaces of ceramic ware consists in applying coating material to the surfaces to be colored, the coating containing a small percentage of copper oxide and silicon carbide, and firing the ware in ordinary kiln atmosphere thereby causing the silicon carbide to react with the copper oxide to produce a characteristic "copper red" color by the reduction of the copper oxide to a lower stage of oxidation.

Designs for

Bottle. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 92,069, April 24, 1934. RAYMOND GUERLAIN (Guerlain Perfumery Corp.). U. S. 92,078, April 24, 1934. C. D. LITTLE (Seminole Flavor Co.). U. S. 92,098, April 24, 1934. N. F. STEUER (Owens-Illinois Glass Co.). U. S. 92,116, April 24, 1934. H. D. KINNEY. U. S. 92,145, May 1, 1934. S. J. MCGIVERAN (Owens-Illinois Glass Co.). U. S. 92,148, May 1, 1934. SOLOMON FORMAN. U. S. 92,243, May 15, 1934.

Drinking glass. E. A. WALTON. U. S. 92,218 and 92,219, May 8, 1934.

Glass bottle. J. A. HARVEY (Fairmount Glass Works, Inc.). U. S. 92,173, May 8, 1934.

Glass goblet. R. C. IRWIN. U. S. 92,247, May 15, 1934.

Glass plate. R. C. IRWIN. U. S. 92,248, May 15, 1934.

Goblet. GEORGE SAKIER (Fostoria Glass Co.). U. S. 92,113, April 24, 1934.

Signal cover glass. CHARLES ADLER, JR. U. S. 92,055, April 24, 1934.

Stove. F. J. FREELAND (Round Oak Furnace Co.). U. S. 92,068, April 24, 1934. S. F. JACKES AND F. W. PAVEY (Jackes-Evans Mfg. Co.). U. S. 92,250, May 15, 1934.

Water closet. J. M. TEAHEN. U. S. 92,215, May 8, 1934.

Decoration of tile, etc. OXVAR, LTD. Brit. 408,894, April 25, 1934.

Cements

Aluminates of hydrated lime. J. LEFOL. *Compt. rend.*, **197** [17], 919–21 (1933).—The dehydration process of calcium aluminates was studied. Hydrated tetracalcic aluminate at 95°C has a hydrate between 10.5 and 11H_2O and, at 175°, another of 6H_2O. It is difficult to remove all H_2O; at 350° 3H_2O are present. Hydrated tricalcic aluminate at 110° has the composition $Al_2O_3 \cdot 3CaO \cdot 21H_2O$; at 135° a hydrate with 8 to 8.5H_2O exists. Cubic hydrated tricalcic aluminate has a stable form of 6H_2O and transforms between 260 to 300° into a hydrate with 1.5H_2O. The bicalcic hydrate has up to 65° 7H_2O; in humid atmosphere it takes up 1 mol. H_2O in 1/4 hr. and 2 mol. in 4 hr. At 65°, dehydration commences and at 150° a hydrate with 5H_2O exists. M.H.

Cement chemical investigations. H. BRITZINGER AND W. BUBAM. *Kolloid-Z.*, **63** [1], 87–93 (1933).—An apparatus is described which is used in investigating the swelling and shrinkage of cements in water by means of changes in viscosity of cement slimes or pastes. Curves and details are given on (1) the influence of the CO_2 content of cement on the lapse of time in the swelling of cements, (2) influence on the lapse of time in the swelling of cements of the additions of water solutions of sugar, water-glass, caustic soda, and sodium aluminate, and (3) the determination of the raising of the corrosion stability of cement through an addition of a water-glass solution. A.K.

Combination of magnesia in Portland cement. H. E.

SCHWIETE AND H. ZUR STRASSEN. *Zement*, No. 9, pp. 114–16 (1934); abstracted in *Tonind.-Ztg.*, **58** [23], 296 (1934).—On the basis of studies of equilibria, the possibilities of the combination of magnesia in Portland cement were studied. It is concluded that spinels are not formed in Portland cement because, although they are formed at high temperature, they disintegrate again on cooling. Magnesia combines with the iron compound of the clinker $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ into $4CaO \cdot 2MgO \cdot Al_2O_3 \cdot Fe_2O_3$; nevertheless, free magnesia is present in the technical clinker owing to a lack of equilibria. M.V.K.

Components of Portland cement and their formation. LENNART FORSÉN. Presented at meeting of Kaiser Wilhelm Inst. for Silicate Studies, 1933; abstracted in *Tonind.-Ztg.*, **58** [15], 181 (1934).—The chief components are (1) alite, $3CaO \cdot SiO_2$, (2) belite, α-$2CaO \cdot SiO_2$, (3) celite, $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$. Alite is the chief carrier of the hydraulic properties of Portland cement. The calcium aluminates present in the basic mix promote the rate of reaction of cement with water because of their solubility. A congealed equilibrium occurs during the technical firing of cement because of its short duration. Products crystallized first in the melt, such as CaO and $CaO \cdot SiO_2$, can not therefore be dissolved further and transformed. $3CaO \cdot SiO_2$ and $4CaO \cdot Al_2O_3$ are stable compositions under technical conditions of firing, while the aluminate $3CaO \cdot Al_2O_3$ (richest in lime) disintegrates into free lime and a melt poor in lime under these conditions. The highest limit of lime is discussed. The processes occurring during cement firing are explained in the following way: in a mixture of tetracalcium aluminate ferrite, tricalcium aluminate, pentacalcium trialuminate, and some calcium silicate, which also contains foreign materials such as alkalis, magnesia, etc., a decomposition of lime and silicate material or of the β-dicalcium silicate formed in the solid phase takes place, by which the formed silicates, tricalcium silicate and α-dicalcium silicate, crystallize. The highest limit of lime is reached in tricalcium silicate and a residual melt without free lime. See also *Ceram. Abs.*, **12** [8], 291 (1933). M.V.K.

Equilibria in colloidal limiting phases. W. EITEL AND H. E. SCHWIETE. Presented at meeting of Kaiser Wilhelm Inst. for Silicate Studies, 1933; abstracted in *Tonind.-Ztg.*, **58** [15], 183 (1934).—When estimating the physicochemical processes in set cement, the equilibria in colloidal limiting phases are of special importance. Such colloids, which possess the property of semipermeable partitions, are formed during hydrolysis of tri- and di-calcium silicates and probably also of tricalcium aluminate and are determinative for the further interchange processes of ions in the liquids within and outside of this colloidal film. The retarding action of gypsum and calcium chloride is determined by the slowing down of the hydrolysis of silicates with a high lime content through an increase of the concentration of the Ca-ions in the liquid outside of the colloidal film. M.V.K.

Existence of three allotropic varieties of calcium. P. BASTIEN. *Compt. rend.*, **198** [9], 831–33 (1934).—Recent measurements of dilatation curves and thermal analysis revealed the existence of 2 allotropic transformations of Ca taking place at 260° and between 430 and 440° so that 3 allotropic variations of Ca exist. M.H.

Nature of Portland cement clinker. H. G. FISK. *Jour. Chem. Ed.*, **11** [4], 195–203 (1934).—Fundamental equilibrium studies on the systems lime–silica and lime–alumina–silica have shown what compounds are possible in Portland cement clinker. Petrographic and X-ray studies have proved the existence of these compounds in commercial cement clinkers. Synthetic studies on the pure compounds and mixtures of them have indicated their functions in Portland cement. The principles of phase equilibria as applied to the Portland cement regions of the lime–silica and the lime–alumina–silica systems are briefly reviewed. The application of thermochemical, petrographic, and X-ray crystal analysis methods to the solution of the problem of the constitution of Portland cement clinker is indicated. A.K.

New researches on the hydration of Portland cement. XI–XII. Hydration of lime silicate in Portland cement. K. KOYANAGI. *Jour. Soc. Chem. Ind.* [Japan], **37** [2], 101–107*B* (1934).—The results are tabulated. For Part X see *Ceram. Abs.*, **11** [5], 290 (1932). M.V.K.

Researches on the hydrates of dicalcium aluminates. H. E. SCHWIETE. Presented at meeting of Kaiser Wilhelm Inst. for Silicate Studies, 1933; abstracted in *Tonind.-Ztg.*, **58** [14], 168–69 (1934).—The important new formations originating during the setting of aluminous cements are the hydrates of the hypothetical dicalcium aluminate and aluminium hydroxide. Hydrates of dicalcium aluminates only were studied; they were prepared by treating a sintered preparation of the composition $2CaO \cdot Al_2O_3$ with ice water. A 9-hydrate was isolated; it converts into the 7-hydrate. The 5-hydrate is stable up to 150°. The 3-hydrate is formed with a slow and then a rapid loss of water; at 400°, the monohydrate is formed which still does not show any traces of free lime. The last traces of H_2O volatilize at 700°. The studies show the probable existence of a 13-hydrate. The X-ray diagram showed new lines in the dehydrate samples pointing to the unstable existence of $2CaO \cdot Al_2O_3$. The determination of the solubility of hydrates was without results. The specific gravity of the hydrates was measured. The results show that the hydrates comprise two groups: the 9- 7- 5-hydrates belong together to one group because the strong lines of the 3 preparations have the same position, while the Debye-Scherrer pictures of the 3- and 1-hydrates show the same lines. The high hydrates (9-7-5) are to be regarded as basic metaaluminates with the univalent anion ($Al(OH)_4$). Because the 5-hydrate has the most unstable combination and the higher hydrates easily lose their water, it is assumed that the loosely combined water of the 9- and 7-hydrates is accumulated in the Ca-ion as aqua-groups. The univalent anion ($AlO(OH)_2$), which is the foundation of trihydrate, originates from the anion ($Al(OH)_4$) by giving off 1 mol. water. By giving off another H_2O mol., the trihydrate changes into monohydrate, a basic Ca-salt of monoaluminate acid of the formula $Ca\langle^{OH}_{AlO_2}$. The analogy of hydrates of tricalcium and dicalcium aluminates is discussed. The heat of solution of separate hydrates was determined in 5*n* HCl. The 5-hydrate is the least energetic compound. M.V.K.

Utilization of fluorspar in manufacture of Portland cement. ANON. *Verre & Silicates Ind.*, **5** [5], 91–92

(1934).—The advantages and disadvantages in using fluorspar in cement are discussed. The opinions of some German scientists are quoted. M.V.K.

Variations in the Neumann-Kopp law in calcium silicates and aluminates. H. Elsner v. Gronow and H. E. Schwiete. Presented at meeting of Kaiser Wilhelm Inst. for Silicate Studies; abstracted in *Tonind.-Ztg.*, **58** [14], 168 (1934).—The determination of the specific heat of CaO,Al_2O_3,SiO_2 was made up to 1500° with great accuracy. To obtain the mean specific heat of minerals ($CaO \cdot Al_2O_3$, $2CaO\ SiO_2$, $3CaO\ Al_2O_3$, $3CaO \cdot Fe_2O_3$, $2CaO\ Al_2O_3$) present in Portland cement and aluminous cement, their values can not be calculated from the specific heat of the components according to the Neumann-Kopp law. The precise determination of the specific heat of these minerals showed certain systematic deviations from the law. These deviations in β-$CaO \cdot SiO_2$ are considerable (up to 7% of the specific heat) and show the same course and magnitude as in $3CaO \cdot SiO_2$. This shows a loose combination of one CaO mol. in $3CaO\ SiO_2$, which agrees with other studies. The deviations from the Neumann-Kopp law are explained by changes in volume during the formation of compounds, the change in the molecular rate of vibration during the transition into another lattice, and analogies with the behavior of other compounds. M.V.K.

Enamels

Acid cleaning and electroplating with rubber-lined equipment. H. E. Fritz. *Metal Cleaning & Finishing*, **6** [4], 159–64 (1934).—Details of the recently developed "anode" rubber coating process and applications of rubber-lined and brick-sheathed equipment in pickling and plating plants are given. E.J.V.

Adherence of sheet-iron enamel. A. Dietzel and K. Meures. *Glashütte*, **63** [51], 866 (1933).—The researches of Schaarschuh (*Ceram. Abs.*, **13** [6], 142 (1934)) are briefly discussed. The authors found that an intermediate layer must be present for the adherence of the enamel. On the basis of reaction and supersaturation phenomena occurring during firing, it was proved that the intermediate layer consists of oxides (chiefly magnetite, Fe_3O_4). Because the intermediate layer is in equilibrium with a melt containing iron in the Fe_3O_4 stage, it is inconceivable that this layer consists of metallic iron. A distinct black "oxide-intermediate layer" is present between the enamel and the sheet iron. This means that the surface of the iron is strongly oxidized by oxygen diffusing through the pores of the enamel. This layer of hammer scale dissolves into the enamel during firing; due to this the concentration in iron oxides increases in the enamel by about 20%. M.V.K.

Ankarsrum's bruk. F. G. Jaeger. *Better Enameling*, **5** [4], 4–5 (1934).—A description of the industry (bruk) in Ankarsrum, Sweden, where J. is acting in an advisory capacity at the enameling plant of the Electrolux refrigerator works, is given. Illustrated. E.J.V.

Attempts to standardize the acid-stability of enamel for household ware. W. Dawihl. *Keram. Rund.*, **41** [43], 567–69 (1933).—Researches of Kerstan (*Ceram. Abs.*, **10** [9], 374 (1927)), Vielhaber (*Keram. Rund.*, No. 27, p. 429 (1927)), Karmaus, and Murawleff and Grigoriev (*ibid.*, No. 41, p. 667 (1927)) dealing with the testing of the resistance of enamels used for cooking utensils are discussed. Experiments of D. dealing with the same subject are described. It was found that the enamels containing boric acid have a low resistance. Enamels have considerably less resistance when they contain 10% boric acid. M.V.K.

Barium nitrate as enamel raw material. Thoma Grote. *Glashütte*, **63** [47], 796–97 (1933).—The advantages of using barium nitrate instead of soda saltpeter, potassium nitrate, and especially minium in the production of different enamels are discussed. See also *Ceram. Abs.*, **13** [5], 110 (1934). M.V.K.

Cheap decorative effects. L. Vielhaber. *Emaillerie*, **1** [7], 19–20 (1933); abstracted in *Emailwaren-Ind.*, **11** [9], 85 (1934).—The method of H. Claus von Claustal (1894), according to which white spots, marbling, etc., are obtained on a gray ground by powdering soda on a still moist coat of enamel containing cobalt and nickel sulfate, is described. Other colorings are obtained with copper or manganese salts. A method of P. Bull (1895) is also described by which the enamel is applied on an unwashed and undried sheet iron with rust. M.V.K.

Cleaning castings. Pangborn Corp. *Ind. Finishing*, **10** [5], 12 (1934).—P. has recently installed in the plant of the Bucyrus-Erie Co. a system which cleans steel castings by water jets operating at a pressure of from 300 to 400 lb. per sq. in. Castings previously requiring 35 hr. for cleaning have been cleaned by this installation in $1^1/_2$ to 2 hr. J.L.G.

Compounds of boron in the porcelain enamel industry and methods of analysis. J. M. Zander. *Better Enameling*, **5** [4], 13–14 (1934).—A description of the chemical and physical properties of borax and boric acid is given. The use of each in porcelain enamel production and their effects on the enamel properties are discussed. Methods of analysis of each are outlined with a method for determining boric oxide in enamel frits. E.J.V.

Cracked cooking utensils. Heinrich Sasse. *Emailwaren-Ind.*, **11** [6], 47–50 (1934).—After discussing the researches of Vielhaber (*Ceram. Abs.*, **13** [2], 33 (1934)) on the cracking of cooking ware and those of Dietzel (*ibid.*, **13** [5], 111 (1934)) on the effect of kaolin in enamels, S. describes the results of his studies. The chief factors for obtaining cooking-stable enameled ware are as follows: (1) use of a sufficiently thick sheet iron (ratio of the thickness of sheet iron to the diameter of the bottom of the ware as much as 1:300–350); (2) solidly adhering, uniform, and thinly applied ground, highly elastic, and a low coefficient of expansion (better results were obtained with enamels having a coefficient of expansion less than 320×10^{-7}); (3) a thin, homogeneous white coating, a low addition to the mill, opacification with SnO_2, a high tensile strength and elasticity, and a coefficient of expansion not over 300;

(4) the melting point of the coat enamel not much lower than that of the ground. Methods for testing enameled cooking ware are briefly reviewed. M.V.K.

Decalcomania. ANON. *Emaillerie*, **1** [7], 13–16 (1933); abstracted in *Emailwaren-Ind.*, **11** [9], 85 (1934).—Directions for obtaining transfer pictures on enamelware are given. Calcining the pictures slowly to 200 to 235° before the firing is recommended. M.V.K.

Electrolytic reactions in vitreous enamels and their relation to the adherence of enamels to steel. HOMER F. STALEY. *Jour. Amer. Ceram. Soc.*, **17** [6], 163–67 (1934).

Enamel and enameling. LOUIS VIELHABER. *Emailwaren-Ind.*, **11** [7], 55–59; [8], 63–66; [9], 79–81; [10], 94–96; [11], 100–102 (1934); *Sprechsaal*, **66** [51], 869 (1933).—After a historical review of enamels and enameling iron, V. discusses structure, character of enamel, technique of enameling, and new fields of application of the industry. According to present knowledge, the enamel is not a homogeneous chemical combination but a solution which has become solid and in which some of the components act like solvents, some are dissolved, and a part remains imbedded in the solution in solid form producing opacity. The knowledge that the good adherence of ground enamel to the iron sheet is possible only by using cobalt or nickel oxides is purely empirical; a chemical explanation of the action of these oxides has never been developed, especially since they are inactive when enameling cast iron. Ground enamel is fired in the presence of a certain amount of air; because of this the iron undergoes oxidation and the layer of oxides reacts with the ground producing the so-called adhering layer showing a crystalline structure (magnetite crystals). The increase of additions of flux to obtain a more fusible enamel is limited because of the increase in the thermal expansion of the enamel. The assumption that the enamel should have the same thermal expansion as the iron was wrong. The enamel composition must be such that its thermal expansion would be 10% less than that of the iron. The purity of the iron is of the greatest importance for good enameling. Muffle kilns lined with silicon-carbide plates were found to be the best for firing enamel. Besides firing the chambers with coal, gas, or oil, electric heating has been introduced, showing many advantages such as the lack of flue gas, easy regulation of temperature, and the elimination of muffles. M.V.K.

Enamel without clay? A. DIETZEL. *Emailwaren-Ind.*, **11** [7], 59 (1934).—Alumina is injurious only when used in such amount as to produce opacification because it affects the homogeneity of the enamel. The opacification depends not on the presence of undissolved or precipitated alumina compounds but on the presence of gas bubbles. M.V.K.

Enameling ice boxes. W. *Glashütte*, **63** [52], 883–84 (1934).—The processes of heating the ware, pickling, preparing the enamel and firing, and enameling the ice box are described in detail. M.V.K.

Enamels. II. W. K. *Verre & Silicates Ind.*, **5** [5], 87–90 (1934).—The paper discusses the comparative properties of enamels. (1) Mechanical properties: (*a*) Specific gravity; this value has no great practical importance. (*b*) Resistance to traction is determined by the force necessary to rupture an enamel sample of a definite size; it can be calculated additively also. (*c*) Compression resistance is important; it is measured by the force necessary to crush an enamel cube having a 1 mm. side. Defects such as fishscales are due to a low value of this property. (*d*) Elasticity is determined by the modulus of elasticity; it may be calculated also by additive means as a function of constituents. (*e*) Hardness is measured on Mohs' scale or calculated. (2) Thermal properties: (*a*) Specific heat has not been studied extensively; it may be calculated from data of analysis and respective coefficients. (*b*) Thermal conductivity is calculated additively. (*c*) Thermal resistance is especially important for chemical apparatus and cooking ware. (*d*) Fusibility; analytical estimation has been developed by Staley and improved by Vielhaber. (*e*) The coefficient of dilatation is of great importance. (3) Optical properties: (*a*) Determination of the refractive index is made according to the law of refraction of Snellius. (*b*) Opacification is produced by diffused luminous rays; the greater the diffusing the stronger is the opacification. It is caused by the refraction or reflection of light. Opacification is present in various forms: The enamel contains insoluble constituents added mechanically; during cooling some materials separate chemically or physically (compounds of Fl, Al_2O_3, CaO, MgO). Opacification may be caused by phenomena of miscibility or by gas bubbles. (4) Devitrification: The selective absorption is a phenomenon by means of which the enamel obtains a homogeneous coloration due to the dissolving of oxides in the vitrified layer. (5) Chemical properties: A careful mixing of raw materials, fusion, and slow cooling are the most important factors for the resistance of enameled ware. For Part I see *Ceram. Abs.*, **13** [6], 144 (1934). M.V.K.

Frit ground for cast-iron enameling. H. J. KARMAUS. *Sprechsaal*, **67** [1], 4–6 (1934).—A detailed discussion is given of the preparation, working, firing, and application of frit grounds on cast-iron pieces. The investigations of W. and O. Kerstan and Vielhaber are discussed. Several frits are analyzed. M.V.K.

Further progress report on the study of gases in enameling iron. A. N. LUCIAN AND KARL M. KAUTZ. *Jour. Amer. Ceram. Soc.*, **17** [6], 167–72 (1934).

German raw materials for the German glass and enamel industries. ANON. *Glashütte*, **64** [1], 3–5 (1934).—Various German minerals and rocks which may be used with success in the production of glass and enamels are discussed. A list of references is given. M.V.K.

Glazes and enamels. BOLLENBACH. *Keram. Rund.*, **42** [2], 18–19 (1934).—Differences between ceramic glazes and enamel fired on metal are discussed. The former are prepared for temperatures from 800 to 1400°C, according to the product, and the latter for temperatures from 600 to 1000°, usually 800 to 900°. Enamel for glass is usually fired at 700°. After discussing the differences between raw and fritted glazes, leadless glazes for low temperatures, whose production is difficult because they absorb sulfuric acid from fuel gas and become dull, are treated. The production of leadless enamels is more simple. Considerable amounts of fluorides are used in enamels. Tin, antimony, zircon oxides, and other preparations are used for opacifying. The application of glazes and enamels differs widely; glazes are applied on porous bodies and enamels on "non-absorbing" metals, which is more difficult and requires a definite consistency of the enamel suspension; they are

also powdered on heated ware. The coefficient of expansion of glazes and enamels must be adapted to their bases which is much easier with enamels, in spite of several enamel coats, than with glazes. Ground enamels containing cobalt and nickel adhere in definite temperature intervals only. The basic difference in firing is that the enameled ware is fired for 4 to 6 min. to 800 or 900° in a muffle, in contrast to other ceramic products; such a short firing time permits the use of easily disintegrating pigments, such as cadmium sulfide. The firing is done in oxidizing atmosphere only. Production of enamel for glass is the most difficult; it is fired at a low temperature and must be acid-stable. These enamels are entirely fritted and, under certain conditions, may serve as coatings for aluminum. M.V.K.

Molding and enameling sanitary ware. J. B. NEALEY. *Iron Age*, **133** [16], 22–23 (1934).—Illustrations and details are given of foundry and enameling practice at the U. S. Sanitary Mfg. Co., Monaca, Pa. A.K.

New raw material for enamel. C. A. OTTERBACH. *Emailwaren-Ind.*, **11** [11], 99–100 (1934).—A new raw material for improving the quality of enamel, especially its durability, has been found. Its chemical analysis is 41.05% silica, 27.22 alumina, 21.38 alkalis, 7.40 lime, traces of manganese dioxide, 0.97 magnesia, 1.78 iron oxide, and 0.2 loss on ignition. Experiments in using it for ground enamel were successful. Enamel batches may contain up to 40% of this material. M.V.K.

New type of continuous furnace. ANON. *Enamelist*, **11** [7], 10–12 (1934).—A detailed description of the Ferro Junior continuous furnace is given. It is an oil-fired "U" type unit having an overall length including chain extension of 58 feet, with a hot zone 6 x 12 feet, and is built to fire about the same amount of ware as two 5- x 12-ft. box-furnaces. Illustrated. E.J.V.

No one-coat tubs. F. A. SPELLER, W. N. HARRISON, A. I. ANDREWS, CLYDE E. WILLIAMS, R. M. KING, E. HOGENSON, AND KARL TÜRK. *Enamelist*, **11** [7], 9 (1934).—The consensus of opinion as to the finishing of washing machine tubs in one coat of porcelain enamel is that the results would not be satisfactory and would tend to depreciate the porcelain enameling industry. E.J.V.

Notes on pressure molding. G. D'ARDIGNY. *Rev. fonderie moderne*, **28**, 45–49 (1934).—The mechanism of molding under pressure is explained and the forces available for manual and machine molding are discussed. The pieces which can be molded have a definite limit in size according to the pressure available, *e.g.*, in manual pressure molding with one arm only exerting the pressure (40 kg./cm.^{2}) the maximum size is 20 cu. cm., with 2 hands and body weight supporting 100 kg./cm.^{2} Arrangements of pressure channels and of molds, shrinking of metal, and removal of pieces from mold are described. M.H.

Opacifying agents for enamel. ANON. *Emailwaren-Ind.*, **11** [4], 25–31 (1934).—There are two methods of opacification: (1) the opacification of the fusion from the outset and (2) an opacification of the clear fusion by grinding with opacifiers. To the first method belong alumina, bone ash, fluorides, and antimony oxide. Alumina has no great opacifying power; it is used chiefly in mineral combination, such as clay, feldspar, and kaolin. Opacifying power is varied depending on the material and on the circumstances under which it is employed. The opacifying power of bone ash is greater than that of alumina, but it increases the melting point of the enamel; precipitated calcium phosphate is used to replace it at present. The opacifying effect of fluorspar or calcium fluoride is comparatively small; the peculiarity of all fluorspar opacifiers is that usually they opacify not by themselves but through new compounds formed. Sodium fluoride is the real opacifying ingredient. The occurrence and mining of cryolite, the effect of natural cryolite on enamel, and the production of synthetic cryolite are discussed. Sodium fluosilicate is used with cryolite or in its place. Antimony oxide is used only in the manufacture of bathtubs, shields, etc. It is a powerful opacifier, but makes the enamel less fusible. Mill opacifiers: Clay has a definite opacifying effect; easily fusible clays opacify less. Tin oxide is less sensitive than other opacifiers and is used extensively. The use of zirconium oxide as an opacifier is discussed; Terrar, an opacifier containing zircon, is widely used. Arsenic oxide is a good opacifier, but is poisonous. Titanium oxide produces a yellowish coloring. The effect of cerous oxide as opacifier is little known although it is used in France. Progress has been made with gas opacification; these gases are water steam, oxygen, nitrogen, and carbonic-acid gas. Among the antimonates, salts of the trivalent antimonic acid ($Sb(OH)_3$) or Sb_2O_3 are used, especially leuconin ($NaSbO_3$). Antimonates can be used in all normal enamels as addition to the mill or to the enamel. Some patents dealing with the opacifiers discussed are briefly analyzed. M.V.K.

Pictorial enamel by brush application. E. R. BRAUNER. *Ceram. Ind.*, **22** [5], 248–49 (1934).—Painting pictures with colored enamels opens a new field. A suitable vehicle has been developed which will suspend the enamels and allow them to flow easily and uniformly from a brush and which can be eliminated in the drying or early stages of firing. In the application of the enamel the artist must be familiar with the difference in the color of the unfired and the fired enamel. Several colors can be fired on in one firing. Illustrated. E.J.V.

Porcelain enamel-on-metal murals. ANON. *Iron Age*, **133** [8], 24–25 (1934).—Illustrations and details are given of a new development in porcelain enamel-on-metal murals with attractive pictorial designs and intricate figures in a range of pleasing colors. A.K.

Porcelain-finished fixtures and wall treatment pay dividends. ANON. *Better Enameling*, **5** [4], 11 (1934).—Remodeling and modernizing the A. Remle Stores in Cincinnati, Ohio, with porcelain-enamel equipment and wall paneling has resulted in sales increase. Illustrated. E.J.V.

Problem of coefficients of expansion. L. VIELHABER *Emaillerie*, **1** [8], 21–24 (1933); abstracted in *Emailwaren-Ind.*, **11** [9], 85 (1934).—The significance of the coefficients of expansion of enamel for enameling is discussed in detail. M.V.K.

Reducing pickling costs. ANON. *Mech. World*, **95** [2468], 375 (1934).—Marked reductions in pickling costs are obtainable by the use of acid-resisting equipment. Illustrated. E.J.V.

Showmanship in sign advertising demands use of porcelain enamel. F. A. ORTH. *Ceram. Ind.*, **22** [5], 260–63 (1934).—Illustrated. E.J.V.

Standard's new model breaks tradition in bathtub design. ANON. *Ceram. Ind.*, **22** [5], 239–40 (1934).—The Neo-Angle bathtub is 4 ft. square, the tub running the diagonal length and providing two commodious seats as integral parts of the unit. This tub is offered in colored and white enamels, both acid-resisting and regular. Illustrated. E.J.V.

The system sodium disilicate–sodium fluoride. HAROLD SIMMONS BOOTH, BERNARD A. STARRS, AND MONROE JOHN BAHNSEN. *Jour. Phys. Chem.*, **37** [9], 1103–1107 (1933).—The ternary system Na_2O–SiO_2–NaF is important in the composition of vitreous enamels. The system is a simple V-eutectic type, no compounds being formed. The eutectic composition is 39.5 ± 0.1 mole % sodium fluoride and the eutectic temperature is 797°C ± 1°C. The melting point of the disilicate is 874°C. The solidus relations below the eutectic temperature have not been studied sufficiently to draw definite conclusions. A.K.

Thermal efficiency in enamel works. II. E. WIEDEMANN. *Glashütte*, **64** [1], 7–9; [2], 21–23 (1934).—The development of various kilns for firing enamel with their advantages and defects is discussed in detail. Illustrated. For Part I see *Ceram. Abs.*, **13** [6], 143 (1934). M.V.K.

BOOK REVIEWS

Enameling of Iron and Cast Iron. V. I. SAVCHENKO. State Sci. Pub. House of Machine-Building, Metal Treatment, and Ferrous Metallurgy, Moscow and Leningrad, 1932. 88 pp., 33 figs. Price 1 R, 50 kopecks. The brochure deals in detail with raw materials, their preparation, enameling upon iron and cast iron, composition and treatment of these metals for enameling, control of manufacture, properties of enamels, and the development of the enameling industry; 21 kinds of defects encountered in enameling cast-iron ware and the cause of their appearance are indicated. A list of Russian and foreign literature on enamels is appended. S. I. PERKAL

Manufacturing Electric Steel in Basic Furnaces. V. M. ZAMOROOYEV. State Sci. Tech. Pub. House, Moscow, 1931. 152 pp., 128 figs. Price 1 R, 50 kopecks. This popularly written book is outlined in 14 chapters as follows: (1) basic data on chemistry, (2) origin of electric steel, (3) basic data on electrical engineering, (4) electrical furnaces, (5) lining and equipment of electrical furnaces, (6) raw materials for electromelting, (7) manufacture of electric steel (basic melting), (8) pouring of electric steel, (9) testing and acceptance of electric steel, (10) troubles in electric-steel manufacture and measures for their prevention, (11) electric-steel melting in U.S.S.R., (12) prime cost of electric steel, (13) main kinds of steel melted in electric furnaces, and (14) tables. The book will be useful for first acquaintance with the process of electric-steel melting. S. I. PERKAL

Glass

Alternating β-γ colorings of $Na_2O{\cdot}2SiO_2$ glasses and reasons for pure violet colorings of glasses free from manganese. J. HOFFMANN. *Mitt. Inst. Radium Forschung*, No. 223 (1933); abstracted in *Sprechsaal*, **67** [13], 190 (1934).—In contrast with sulfate and sulfide residuals, carbonate or CO_3 residuals do not cause blue or violet colorations in sodium-silicate glasses from exposure. The yellow coloring of disilicate glasses when exposed is conditioned by sodium-iron-oxygen compounds. Exposure products colored violet were obtained only when mono- and di-silicate melts were melted in a platinum crucible; these melts were practically free from Fe and Pt, although it is possible that traces of dissolved Pt, which are no longer chemically detectable, may play a considerable rôle in the appearance of the violet color on exposure. This vanishing small amount of platinum colors the melt yellow, but the congealed glass shows no color. Larger quantities of Pt color the melt red-brown, while the glasses become amber-yellow. Attempts to change the yellow coloring to violet by distinctive thermal treatments of $Na_2O{\cdot}2SiO_2$ melts were unsuccessful. Chilled $Na_2O{\cdot}2SiO_2$ melts showed black-gray colors when exposed. The gray-black coloring is ascribed to "accumulated unstable silica." As reasons for the violet colorings, $Na_2O{\cdot}SiO_2$ or Na_2O are regarded as monoforms. M.V.K.

Concerning frosting troubles. ANON. *Glass Ind.*, **15** [4], 51–52 (1934).—Several theories that have been advanced to explain the process of frosting or matt etching are discussed and the generally accepted protection theory is taken up in detail. The general frosting solution formula and the effects obtained by variation thereof are explained. The action of the solution on the glass and precautions necessary to insure uniform frosting are described. Illustrated. E.J.V.

Constitution and color of uranium glasses. W. WEYL AND E. THÜMEN. *Sprechsaal*, **67** [7], 95–97 (1934).—Uranium was converted into the uranous state in glasses melted in strongly reducing conditions with metallic aluminum as a reducing agent. Gray-green glasses result. $Na_2O,4SiO_2$ glass with 10% sodium uranate is colored gray-green in a reducing melt; a potash silicate glass of a corresponding composition produces more brown tones. This difference in color is due to the fact that potash glass transmits relatively more red; the absorption band in red is lower in potash glass than in soda glass. The red permeability considerably increases when boric acid is added. Boric acid effects a relatively strong change in the absorption spectrum, as in chromium glasses, because of the formation of complex compounds. Some crystallized complexes derived from uranous oxalate show gray to red-violet colorings, while others show the specific green color of uranium ions. Soda borosilicate glasses are colored gray-violet by uranium oxide; the absorption spectrum of a uranium glass of the composition $Na_2O{\cdot}B_2O_3{\cdot}4SiO_2$, with an addition of 5% sodium uranate, is shown. Under normal melting conditions, only secondary uranous compounds are formed. Compounds derived from uranium trioxide are formed chiefly, uranium trioxide being used as a base or acid in the glass composition. Uranate glasses are formed preferably when the uranium oxide is introduced

into a strongly basic melt and especially when a large amount of uranate, in the form of lead uranate, separates in the form of crystals as happens with some uranium red lead glazes. Uranyl compounds, in contrast to uranous compounds and uranates, fluoresce, which explains the strong fluorescence of uranium glasses containing boric acid. M.V.K.

Control of the degree of purity of fluxes employed in glass compositions. R. D. *Verre & Silicates Ind.*, **5** [6], 108–10 (1934).—Sodium carbonate: Solvay soda is used extensively; it contains 97 to 99% Na_2CO_3, 0.3 to 0.2% NaCl, little Fe_2O_3, and insoluble residue. The principal factor to be determined is the water content. Some kinds of soda contain 8 to 10% Na_2SO_4; this variety melts more easily and promotes refining. The density of soda depends on the temperature of calcining; the higher it is, the more dense is the soda. Analyses of different soda samples are given. Sodium sulfate is obtained by treating NaCl with H_2SO_4. Its iron oxide content varies from 0.094 to 0.18%. The composition of sodium sulfate is varied; it should not contain more than 0.5% NaCl and the H_2SO_4 content should be low. Analyses of different sulfates are given. Potassium carbonate: calcined potash is hygroscopic and absorbs much water. Analyses of potash are given. Crystallized potash (K_2CO_3 $2H_2O$) is advantageous. Water reduces the values of all these fluxes. NaCl and Na_2SO_4 are detrimental and capable of causing defects (gall and yellow glass). The total replacement of one flux for another of the same nature but different origin may give poor results. M.V.K.

Dairies adopt bottle tests. ANON. *Glass Ind.*, **15** [4], 53–55 (1934).—The Chicago Milk Dealers Bottle Exchange is conducting tests on practically every carload of milk bottles shipped into the greater Chicago bottling area. The tests made are distribution and weight, polariscope, capacity, hydrostatic pressure, temperature shock, and impact. Details of each test are given. Illustrated. E.J.V.

Design of glassmelting tank furnace for bottle plant. L. O. GESBURG. *Ukrainsky Silikaty*, No. 3, pp. 60–72 (1932).—The description of the tank at Borzholm and the calculations involved in its design are outlined in detail. S.I.P.

Determination of homogeneity of glass batch and the factors influencing it. M. F. SHUR AND P. V. VASSILYEV. *Ukrainsky Silikaty*, No. 1–2, pp. 17–23 (1932); see also *Ceram. Abs.*, **11** [9], 485 (1932). S.I.P.

Development of mechanical methods of glass manufacture in Europe. W. E. S. TURNER. Presented at meeting of Society of Glass Technology, Sheffield, April, 1934; abstracted in *Pottery Gaz.*, **59** [683], 591–96 (1934). E.J.V.

Effect of the anion of raw material on the properties of glass. III. K. NAKANISHI. *Jour. Soc. Chem. Ind.* [Japan], **37** [2], 64–65*B* (1934).—The effects of sulfate, carbonate, or sulfur on the durability of glass were studied. It was found that (1) the batch containing alkali-sulfate produced more durable glass than that containing alkali carbonate and (2) sulfur increased the durability of glass containing alkalis. For Part II see *Ceram. Abs.*, **11** [8], 448 (1932). M.V.K.

Electrolysis of glass at high temperatures. R. SCHWARZ AND J. HALBERSTADT. *Z. anorg. allgem. Chem.*, **210** [3], 286–88 (1933).—A Thüringer glass was used for the experiments, and measurements were made from 550 to 1000°C. A copper anode was used. The electric conductance in glass up to 1000° is purely electrolytic. Above 700° copper goes into solution in the glass as a univalent ion and below 700° as a bivalent ion. The sodium which separates cathodically during electrolysis appears in the glass as a blue sol. L.T.B.

Electrolysis of sodium through Pyrex brand glass. EUGENE W. PIKE. *Rev. Sci. Instruments*, **4** [12], 687 (1933).—A method is described for introducing gas-free sodium into a vacuum tube by electrolysis through Pyrex brand glass. A.K.

Employing blast-furnace slag in the manufacture of glass. OTTO VOGEL. *Glashütte*, **63** [50], 849 (1933).—American attempts to manufacture glass with blast-furnace slag are discussed. M.V.K.

Essentials of glass technology based on American practice. VIII. SAMUEL R. SCHOLES. *Ceram. Ind.*, **22** [5], 264–66 (1934).—A detailed description of the construction of a "bottle tank" rated at 40 T. daily capacity, fired with producer gas with regeneration, is given. Illustrated. For Part VII see *Ceram. Abs.*, **13** [6], 146 (1934). E.J.V.

Expansion of molten silica. L. DUNOYER. *Compt. rend.*, **198** [12], 1132–34 (1934).—The method of measurement is described. The expansion coefficient was determined to about -6.6×10^{-6}, *i.e.*, a negative value. M.H.

Formation of cristobalite octahedrons in devitrified glass. MARCEL BELLIÈRE. *Verre & Silicates Ind.*, **5** [6], 102–103 (1934).—Illustrated. M.V.K.

Formation of sodium sulfate in oil-fired glass furnaces. W. R. LESTER. *Glass Ind.*, **15** [4], 61 (1934).—Only one case of the formation of "salt-water" in a glass furnace fired by oil over a period of several years has been found. However, sodium sulfate, formed from sulfur in the fuel, has attacked the refractories. Data on condensed material taken from beside tank "sting-outs" show that sodium sulfate is actually present in the atmosphere. Analysis of typical slags taken from checker brick and from the flues also shows the presence of a large quantity of sodium sulfate. E.J.V.

Glass: the bond in ceramics. GEORGE W. MOREY. *Jour. Amer. Ceram. Soc.*, **17** [6], 145–55 (1934).

Glassmaking in South Africa. ANON. *Cape Argus*, 13 (Feb. 10, 1934).—The only glass factory in the Union is at Talana Hill, Dundee. It was started during the World War. All the raw materials are obtained within the Union, except soda ash and arsenic. The ware is fired to 1400°C. The life of a furnace is about 7000 T. of glass. Bottles, before being passed for sale, are tested up to 500 lb. pressure by a government inspector. H.H.S.

Glassmelting and glassmelting furnaces. I. I. KITAIGORODSKIĬ. Presented at International Ceramic Congress, Milan, 1933; abstracted in *Keram. Rund.*, **41** [44], 583 (1933).—Processes taking place during glassmelting, from the charging of the furnace to the formation of the finished glass, are discussed from a theoretical viewpoint. The attempt to increase the output and to improve the quality of the glass according to ideas of Fergusson,

Küntzel, and Zotos (*Ceram. Abs.*, **11** [12], 625 (1932)) were not successful because the separate processes occurring during the glassmelting were not given sufficient consideration. M.V.K.

Glass melts. HUGO KÜHL. *Glashütte*, **63** [46], 770–74 (1933).—Technical glass, with the exception of quartz glass, is not a chemical combination. As such it should be built up according to stoichiometric laws, but this is not the case when double silicates, which have characteristics of glass, are produced. However, stoichiometric laws are of the greatest significance for the synthesis of a glass composition. The ordinary soda-lime glass is characterized by the system Na_2O–CaO–SiO_2. The normal glass contains $6SiO_2$ (75%), $1Na_2O$ (12.9%), 1CaO (11.6%), hence it can be regarded as a solution of sodium and calcium silicates in silica. Glass is a homogeneous mixture from the physical viewpoint, and in this respect has much in common with alloys of the metal industry which are homogeneous and eutectic only when no precipitation results from the solution of metals and nonmetals. In the glass industry, a devitrification of separation is artificially caused as in brown gold aventurine glass and in milk glass; the glass melt is composed in such a way that it precipitates numerous small crystals on cooling. Alumina and magnesia, in spite of their great importance and valuable properties for the production of quality glass, may produce devitrification, streaks, and stones. Devitrification, as a result of an inhomogeneous melting, is easily produced. Attempts to produce usable glasses on a stoichiometric basis are discussed. A glass was melted from a batch containing 2 mol. magnesium oxide, 2 mol. tin oxide, 1 mol. sodium oxide, 8 mol. silica, and 2 mol. boric acid anhydrite. Sodium-zinc silicates melted with sulfate produce glass with a technical character. M.V.K.

Glass transmits 70% of sun's energy and only 30% heat. CORNING GLASS WORKS. *Ceram. Ind.*, **22** [3], 130–31 (1934).—Aklo glass is said to transmit 70% of the visible energy in the sunlight which strikes it and to hold back the heat rays so that barely 30% of them pass through the window. This glass, which is green, will serve as a boon to the air-conditioning industry because a minimum of heat and cold will pass through the Aklo windows of air-conditioned homes, thus effecting a saving in conditioning expense. E.J.V.

The great enigma. F. W. PRESTON. *Glass Ind.*, **15** [4], 57–59 (1934).—Discussing the work of various investigators on physical changes in glass, P. shows that evidently more work is necessary as there are discrepancies in the various laws developed by the different scientists. E.J.V.

Grinding and polishing plate glass. ANON. *Elec. World*, **103** [3], 120 (1934).—An impressive installation of 52 unit motor drives in a single line, of which 22 are grinders and 30 are polishers, is illustrated. A.K.

Holmegaard's glassworks. ANON. *Danish Foreign Office Jour. Commercial Rev.*, **13**, 179–80 (1933).—Founded in 1825, Holmegaard makes domestic, pressed, and art glass and glass packing. Its newest development is engraved glass cut on a copper wheel. Illustrated. H.H.S.

Machine for winding springs of vitreous silica. H. W. WEINHART. *Rev. Sci. Instruments*, **4** [6], 350–52 (1933).—Illustrated. A.K.

Machining glass with sintered carbide tools. KARL SCHROETER AND A. FEHSE. *Iron Age*, **133** [17], 14–17 (1934).—The authors present a comprehensive review of tested shop practices in machining glass. A.K.

Manufacture of sheet and plate glass. R. M. WEEKS. *Nature*, **133** [3358], 347–48 (1934).—An account of a lecture describing the manufacture of sheet and plate glass is reported. Illustrated. J.L.G.

New chain conveyer designed for glass manufacturing. DIAMOND CHAIN & MANUFACTURING CO. *Glass Ind.*, **15** [4], 66 (1934); *Ceram. Ind.*, **22** [5], 278 (1934).—Illustrated. E.J.V.

New food can uses glass "window top." ANON. *Ceram. Ind.*, **22** [5], 241 (1934).—The Continental Can Co., in conjunction with the Corning Glass Works, has developed a new "window-top" can which permits display of canned foods without opening the container. No changes in the canning process are involved in using this new can. Illustrated. E.J.V.

New glass prevents moisture on inside of windows. PITTSBURGH PLATE GLASS CO. *Ceram. Ind.*, **22** [5], 242 (1934).—To overcome the condition where moisture forms on the inside surfaces of ordinary glass and causes the white scum known as bloom, a potash glass, "Water-White Plate Glass," has been developed. E.J.V.

New method of toughening glass. CH. WILKE. *Chim. & ind.*, **31** [2], 485 (1934).—The chilling of glass causes a state of supertension. The chilling necessary for high tensions has been obtained by the Siemens method, *e.g.*, heated glass plates were chilled between two metallic plates cooled by water. According to Reiss' new method, glass plates are suspended with pliers, heated above their softening point, and immersed in a strong current of air passing through a tubular frame. The frame is rotated and the air escaping from the pipes cools the entire surface of the glass. This method avoids the operation of polishing and finishing. Plate glass obtained in this way shows a resistance to flexion of 2000 to 2900 kg./sq. cm. M.V.K.

Notes on the manufacture of colorless glasses. No. 26. ANON. *Glass*, **11** [4], 140–43 (1934).—This article is a general summary of the articles on annealing, durability, and endurance. For Nos. 15, 16, and 25 see *Ceram. Abs.*, **13** [6], 146 (1934). A.J.M.

Preparation of sodium carbonate free from iron oxide. W. H. WITHEY. Presented at meeting of Society of Glass Technology, Sheffield, April 18, 1934; abstracted by title in *Pottery Gaz.*, **59** [683], 596 (1934). E.J.V.

Progress of the glass industry in 1932. III. OSCAR KNAPP. *Glashütte*, **63** [49], 831–33 (1933).—The chief topics briefly discussed are (1) acid stability of glass in dependence on the chemical composition, (2) effect of thermal treatment on the opacification of opal glass, (3) effect of sand moisture on the homogenization of the batch, (4) action of manganous oxide in the batch, (5) electric glass-melting, (6) processes occurring when etching glass, (7) sources of defects when silvering glass, (8) corrosion stability of glasspots, (9) thermal conductivity of refractories, (10) effect of grain size on the properties of refractory aluminous products, (11) determination of silica, (12) determination of boric acid by distillation, (13) separation and determination of titanium, (14) determination of

fluorine, and (15) viscosity of glasses. References are given. For Part II see *Ceram. Abs.*, **13** [6], 147 (1934).
M.V.K.

Quality of bottle and pressure testing. KURT H. BORCHARD. *Sprechsaal*, **67** [9], 121–22 (1934).—The durability strength or pressure in atmospheres that bottles endure amounts to about $^1/_2$ to $^1/_3$ of ordinary pressure in atmospheres at which the bottle is crushed when the pressure is increased rapidly up to crushing. Measurement of the crushing strength conveys a false conception of the practical strength of bottles. Only the durability test can give a clear idea. An apparatus used for such tests is briefly described.
M.V.K.

Remarks on the optimum properties of night-glasses. V. ROCARD. *Rev. d'optique*, **11**, 352–61 (1932); abstracted in *Z. Instrumentenk.*, **53** [7], 331–33 (1933).
M.H.

Review of recent experiments in the decolorization of glass. W. E. S. TURNER. Presented at meeting of Society of Glass Technology, Stourbridge, March, 1934; abstracted in *Pottery Gaz.*, **59** [683], 596 (1934).
E.J.V.

Special uses of glass. OTTO HERFURTH. *Diamant*, **56** [8], 85–87 (1934).—The use of glass in the illuminating industry, and in optics, chemical and medicinal glass, special building glass, and safety glass is discussed.
M.V.K.

Structure of glass. B. LENGYEL. *Magyar Chem. Folyóirat*, **39** [5–8], 73–82 (1933); abstracted in *Chim. & ind.*, **31** [3], 603 (1934).—Devitrification is probably due to the formation of crystalline knobs in the melt during slow cooling of the glass. It is evident that transparent glass has no crystalline structure; it is a solidified solution in which the oxides of vitrification, especially silica, are solvents in relation to alkaline and alkaline-earth bases. Glass does not have a definite chemical composition; it was found that the electrical conductivity of a fused glass with additions of chlorides equals, *grosso modo*, the sum of the conductivity of its components. When cooling fused glass, viscosity increases rapidly beginning with a certain temperature, due to a polymerization of molecules. According to Zachariasen, this polymerization produces a slight dissymmetry and an increase of the free energy of the system in relation to the crystalline state. Only oxides or the deposition of atoms facilitates the dissymmetric polymerization.
M.V.K.

Thermal expansions of some soda-lime-silica glasses as functions of the composition. B. C. SCHMIDT, A. N. FINN, AND J. C. YOUNG. *Bur. Stand. Jour. Research*, **12** [4], 421–28 (1934).—The linear thermal expansions from 25°C to the "critical" and "softening" temperatures were determined for 19 soda-silica and 30 soda-lime-silica glasses by the interferometer method. Graphs have been prepared from which the critical temperature, softening temperature, the expansion to these temperatures, and the annealing range can be predicted approximately for any glass in the range of compositions studied, *viz.*, between approximately 12 and 50% soda, 0 and 20% lime, and 50 and 80% silica.
R.A.H.

Transformation and softening point of glasses. E. RENCKER. *Compt. rend.*, **197** [19], 1049–51 (1933).—Recent tests with many types of glasses have proved that the transformation point, *i.e.*, a point where the temperature coefficients of all physical properties change suddenly, coincides with the temperature at which the glass begins to soften. See also *Ceram. Abs.*, **13** [4], 83 (1934).
M.H.

Use of rocks in the glass industry of U. S. S. R. S. I. PERKAL AND I. S. SHUR. *Ukrainsky Silikaty*, No. 1–2, pp. 24–28 (1932).—The authors deal with the use of nephelines, pegmatites, andesites, trachytes, "volcanic ashes," and other rocks for glass manufacture by hand and by machinery. The following batches are given:

I		II		III	
Nepheline	1000 kg.	Pegmatite	1100 kg.	Volcanic ash	1000 kg.
Sand	890 "	Sand	1000 "	Soda	102 "
Soda	245 "	Soda	450 "	Chalk	238 "
Chalk	536 "	Chalk	630 "		

S.I.P.

Water attack of lime-alkali-silica glasses. GUSTAV KEPPELER AND MAX THOMAS-WELZOW. *Keram. Rund.*, **42** [6], 69–71; [7], 81–83; [8], 96–99; [10], 122–24; [11], 136–38 (1934).—Eighteen melts of the range of soda-lime-silica glasses were analyzed and their solubility was determined. The law governing the dissolving rate of the glass was found. The amount of alkali dissolved by water from a unit of surface is a parabolic function of the dissolving time, *e.g.*, their square is proportional to time. The validity of this law was tested on time-solubility measurements; the results confirm the researches of other investigators. A method for characterizing the surface of glass is developed. The relationship between the dissolving time and the composition of glass was determined. No conclusions could be drawn on the constitution of glass from this relationship. See also *Ceram. Abs.*, **13** [4], 85 (1934).
M.V.K.

BOOK REVIEWS

Astronomical Telescope from Spectacle Glasses. A. A. CHIKIN. 60 pp. State Technical Theoretical Publishing House, Moscow and Leningrad, 1932. Price 59 kopecks. (*J.S.G.T.*)

Glass Manufacture by the Fourcault Process. G. E. SHAPIRO. 72 pp. Publishing House "Ukrainian Worker," Charkov, 1931. Price 40 kopecks. (*J.S.G.T.*)

Glass Technique. Manual of study for the Glass Industry. I. S. SHUR. 444 pp., 220 illustrations. State Chemico-Technical Publishing House, Moscow and Leningrad, 1933. Price 6 R. (*J.S.G.T.*)

Manual for the Treatment of Optical Surfaces. V. A. OSSIPOV. 80 pp., 49 illustrations. Leningrad, 1931. Price 1 R, 35 kopecks. (*J.S.G.T.*)

Optics and Glass. Their Historical Development. V. I. LEBEDEV. 192 pp., 50 illustrations. First Timiryazev Scientific Research Institute, Vologda, 1928. Price 2 R, 50 kopecks. The history of optics and glass is outlined under the following nineteen headings: (1) Glassmaking of the ancient cultural peoples, (2) Optics of the ancient cultural peoples, (3) Glassmaking in the Middle Ages, (4) Optics of the ancient Arabians, (5) Who invented spectacles? (6) Glassmaking in the 15th and 16th Centuries, chronology of discoveries in glass and optics before the beginning of the 17th Century, (7) Glassmaking and chronology of its discoveries in the 18th Century, (8) History and discoveries of optics in the 17th Century, (9) His-

tory of the telescope, (10) History of the microscope and chronology of discoveries regarding its construction, (11) History of the refractor and chronology of discoveries of its construction, (12) History of glass in the 18th and 19th Centuries, (13) History and chronology of discoveries of optics in the 18th Century, (14) History of optical glass in the 19th Century and chronology of discoveries of glass-making in the 18th and 19th Centuries, (15) History of the reflector, (16) History of crystalloptics, (17) History of spectroscopy and chronology of its discoveries, (18) History and chronology of discoveries on photography and photographic objectives, (19) Theories of light in the 19th Century and chronology of discoveries on optics in the 19th Century. Numerous useful data are readably presented. (*J.S.G.T.*)

PATENTS

Annealing leer. R. P. CALLARD (Libbey-Owens-Ford Glass Co.). U. S. 1,957,132, May 1, 1934.

Apparatus for feeding predetermined different weights of molten glass. J. T. WOOD. U. S. 1,955,869, April 24, 1934.

Apparatus for inspecting glass. D. H. BOGGS AND W. J. HEFNER (Pittsburgh Plate Glass Co.). U. S. 1,956,165, April 24, 1934.

Apparatus for making composite glass. E. L. FIX AND B. J. DENNISON (Duplate Corp.). U. S. 1,956,168, April 24, 1934.

Apparatus for making sheet glass. J. S. GREGORIUS (Pittsburgh Plate Glass Co.). U. S. 1,956,170, April 24, 1934.

Apparatus for melting vitreous materials. H. F. HITNER (Pittsburgh Plate Glass Co.). U. S. 1,956,171, April 24, 1934.

Bifocal lens. H. A. TOULMIN, JR. (Univis Corp.). U. S. 1,958,729, May 15, 1934.

Furnace construction. K. B. FAULKNER (Corning Glass Works). U. S. 1,955,956, April 24, 1934.

Glass edge working machine. K. A. WEBER. U. S. 1,958,526, May 15, 1934.

Glass grinding apparatus. F. B. WALDRON (Pilkington Bros., Ltd.). U. S. 1,956,781, May 1, 1934.

Glass tank. GEORGE DOUGHERTY (Morgantown Glass Works). U. S. 1,957,252, May 1, 1934.

Glassware shaping apparatus. C. F. MILLER, JR. (Lynch Corp.). U. S. 1,957,410, May 1, 1934.

Laminated safety glass. G. H. MURRAY. U. S. 1,958,013, May 8, 1934.

Leer stacker. E. F. ANGER (Standard Bottle Co., Ltd.). U. S. 1,957,573, May 8, 1934.

Method and apparatus for forming hollow glassware. K. E. PEILER (Hartford-Empire Co.). U. S. 1,955,765, April 24, 1934. G. E. ROWE (Hartford-Empire Co.). U. S. 1,956,203, April 24, 1934.

Method and apparatus for making safety glass. J. H. SHERTS (Duplate Corp.). U. S. 1,959,221, May 15, 1934.

Method of casting metal fixtures on glass articles. R. D. SMITH (Corning Glass Works). U. S. 1,955,981, April 24, 1934.

Method of decorating articles. A. H. STEWART (Phoenix Glass Co.). U. S. 1,958,595, May 15, 1934. The method comprises applying a decalcomania to a surface to be decorated by wetting a sheet to which the decalcomania is attached by a water-soluble glue, removing the sheet, and applying a transparent protecting sheet to the exposed surface of the decalcomania while the latter is still wet.

Method of manufacturing glass reflectors. C. R. PALMER AND C. E. ANDERSON. U. S. 1,958,859, May 15, 1934.

Method for pouring glass. ANDRÉ DO HUU CHAN (Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny et Cirey). U. S. 1,955,952, April 24, 1934.

Method of treating rolls for use in the manufacture of ornamental flat glass. FREDERICK GELSTHARP AND P. R. MORRIS (Pittsburgh Plate Glass Co.). U. S. 1,956,169, April 24, 1934.

Opaque glass. J. C. PARKINSON (Pittsburgh Plate Glass Co.). U. S. 1,956,176, April 24, 1934. A cream-colored opaque glass formed by fusing together a white glass batch including a fluorine compound and an aluminum compound and coloring ingredients comprising rouge, sodium uranate, and selenium in the following proportions: batch about 2000 lb., rouge 4 to 10 lb., sodium uranate 2 to 7 lb., and selenium 2 to 10 ounces.

Ophthalmic lens. E. D. TILLYER (American Optical Co.). U. S. 1,957,116 and 1,957,117, May 1, 1934.

Process and apparatus for grading finely divided material. R. A. MILLER (Pittsburgh Plate Glass Co.). U. S. 1,959,212, May 15, 1934.

Process and apparatus for making case hardened glass. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,959,215, May 15, 1934.

Process and apparatus for surfacing plate glass. F. V. WILHELM AND T. K. GREGORIUS (Pittsburgh Plate Glass Co.). U. S. 1,959,225, May 15, 1934.

Sheet glass manufacture. NICKLAS FRANZEN (Mississippi Glass Co.). U. S. 1,956,860, May 1, 1934.

Annealing or cooling of glassware. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND W. A. MOORSHEAD. Brit. 408,494, April 18, 1934.

Glass furnace. W. E. EVANS (O'Neill Machine Co.). Brit. 408,265, April 18, 1934. E. FECHOZ. Brit. 409,038, May 2, 1934.

Machines for making hollow glassware. UNITED GLASS BOTTLE MANUFACTURERS, LTD., T. C. MOORSHEAD, AND E. P. DORMAN. Brit. 408,517, April 18, 1934.

Machine for manufacturing glass vessels from glass tubes. J. DICHTER. Brit. 408,450, April 18, 1934.

Optical glass. JENAER GLASWERK SCHOTT & GEN. Brit. 408,993, May 2, 1934.

Process and apparatus for the production of wire glass. A. H. STEVENS (Mississippi Glass Co.). Brit. 409,065, May 2, 1934.

Process of manufacturing frosted bulbs for electric incandescent lamps. TEIKOKU SHOJI CO., INC. Brit. 408,437, April 18, 1934.

Annealing leer for sheet glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY ET CIREY. Ger. 579,040, June 1, 1933. The leer is formed so that the center of the roof is lower than the sides from the entrance to just beyond the annealing zone, the difference in level diminishing gradually until the levels become the same at this point. (*J.S.G.T.*)

Automatic bottom-forming machine for ampoules. J. DICHTER. Ger. 578,193, May 18, 1933. In a machine for melting off ampoule blanks to form the bases in which the blanks are fed to the several stations of the machine by an intermittently acting feeding device, the individual blanks are brought to the first working position from the feeding chute by members gripping them on the shoulders and are fed on to subsequent positions by the same or similar means. (*J.S.G.T.*)

Automatic raising and lowering of polishing tools in automatic polishing machines. BAYERISCHE SPIEGELGLASFABRIKEN BECHMANN-KUPFER A.-G. Ger. 576,758, May 4, 1933. The tools are mounted on frames carrying rollers running on a cam track which imparts the movement necessary to raise and lower the tools from the work. (*J.S.G.T.*)

Construction of the sole of annealing chamber for sheet glass. Y. BRANCART. Ger 580,568, June 29, 1933. The refractory blocks comprising the sole are held together by rods running through them both longitudinally and transversely, springs being provided at each end of each rod to maintain a yielding pressure. (*J.S.G.T.*)

Continuous grinding and polishing of plate glass. C. HEUZE. Ger. 576,063, April 20, 1933. The cars carrying the sheets down the track below the grinding and polishing tools are linked together at the side next the turning wheel which serves to change the direction of the cars. (*J.S.G.T.*)

Continuous spinning of glass threads. W. RÖSSLER. Ger. 564,700, Nov. 3, 1932. An opening at the bottom of a container holding molten glass has a number of trough-like lips from the tips of which the threads of glass are drawn off. The width of these spinning holes is controlled by an adjustable slide. (*J.S.G.T.*)

Control of the ladle during casting process. Y. BRANCART. Ger. 576,728, May 4, 1933. In a process for making sheet glass involving the ladling of glass from a furnace and casting it on to a rolling table, means are provided for controlling both the longitudinal and cross motions of the ladle electrically, the controls being located at the handle of the ladle. (*J.S.G.T.*)

Cooling rollers in production of sheet glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY ET CIREY. Ger. 577,728, May 18, 1933. The local cooling of the rolls described in Ger. 535,014 (*Ceram. Abs.*, **11** [6], 365 (1932)) is continued during rolling as well as previous to the operation. (*J.S.G.T.*)

Cutting blown hollow ware off the pipe. SOC. À RESPONSABILITÉ LIMITÉE G. DURAND & CIE. Ger. 580,455, June 22, 1933. A cooled knife pivoted on an axis above adjustable rollers on which the pipe bearing the blown article is rotated is brought into contact with the glass and cuts it at the required point. After this the pipe is laid on steeply inclined rails below the rollers so that it rolls away from the machine. (*J.S.G.T.*)

Cutting glass sheet. PILKINGTON BROS., LTD. Ger. 577,001, May 4, 1933. Wheels are mounted before and behind the cutting tool in a loading frame in such a way that the tool is lowered on to the glass surface when just past the leading edge of the latter and not before and is raised just before the back edge of the sheet comes under the tool. (*J.S.G.T.*)

Device for drawing tube or rod. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN AND L. S. VELLO. Ger. 579,588, June 15, 1933. Means are provided for adjusting the length of the drawing bed between the drawing chamber and the traction machine at will during the actual operation of the plant. (*J.S.G.T.*)

Downward drawing of tube and rod. P. BORNKESSEL. Ger. 581,505, July 13, 1933. In a method of producing tube or rod by downward drawing through a downwardly tapered orifice in the bottom of a container, a conical mandrel is located in the orifice but does not project through it. The mandrel is hollow and air is blown through to form a tube. (*J.S.G.T.*)

Drawing colored sheet glass by the Fourcault process. H. KNOBLAUCH. Ger. 576,340, April 27, 1933. Colored glass is melted in a container provided with a bridge in a separate compartment of the furnace and discharged into an extension of the debiteuse provided with a channel that opens into the slot proper below the level of the glass in the main container so that it is drawn up with the sheet. (*J.S.G.T.*)

Glass resistant to attack by metallic vapors. JENAER GLASWERK SCHOTT & GEN. Ger. 574,755, March 30, 1933. A glass resistant to metallic vapors has the following composition: B_2O_3, at most 45% Al_2O_3, tetravalent oxides Sb_2O_3, As_2O_3, PbO, and alkali oxides together less than 5%, at least 6% and not more than 80% divalent oxides, and the sum of one and a half times the content of divalent oxides (except PbO) and Al_2O_3 at least 45% of the whole. (*J.S.G.T.*)

Glasses decolorized by rare-earth oxides. DEUTSCHE GASGLÜHLICHT-AUER-G.M.B.H. Ger. 571,017, Feb. 2, 1933. To accentuate the red tint when decolorizing glass by means of rare-earth oxides, gold, cuprous oxide, or selenium in small amounts is employed in addition. (*J.S.G.T.*)

Grinding facets on glass sheets. BAYERISCHE SPIEGELGLASFABRIKEN BECHMANN-KUPFER A.-G. Ger. 580,616, June 29, 1933. The glass is pressed against the horizontal grinding or polishing rollers by an adjustable weight located on a bar parallel to the facet being ground, upward or downward motion of the bar serving to raise or lower the weight of the glass. (*J.S.G.T.*)

Machine for rough-grinding bevelled edges on glass. ÉTABLISSEMENTS MÉTALLURGIQUES ET FONDERIES DE MOUSTIER-SUR-SAMBRE. Ger. 582,836, Aug. 10, 1933. In a machine for rough-grinding beveled edges on oval glass plates in which the plate is carried on a template movable in its own plane and in contact with two members bearing grinding wheels, the plate being driven by a wheel engaging a guide suitably disposed on the edge of the plate, the amount of overhang of the plate beyond the guide is proportional to the radius of curvature of the edge at that point. (*J.S.G.T.*)

Maintaining temperature of heatless leers during stoppages. GLACERIES DE LA SAMBRE SOC. ANON. Ger. 576,343, April 27, 1933. To maintain the temperature of heatless leers during long stoppages of machines, means are provided for tightly closing the trunks supplying cooling medium, the insulation of the leer being so chosen as to

keep in the heat until restarting without having to supply any from external sources. (*J.S.G.T.*)

Melting glass for making glass wool. FIRMA O. GOSSLER. Ger. 580,502, June 29, 1933. A massive walled corrosion-resisting iron alloy container is used, and the glass is melted by the application of less than 50 volts across it. One or more current-carrying bridges can be immersed in the fluid glass. (*J.S.G.T.*)

Polishing facets on sheet glass. BAYERISCHE SPIEGELGLASFABRIKEN BECHMANN-KUPFER A.-G. Ger. 579,134, June 8, 1933. Pressure fingers are arranged relatively close together along the axis of the polishing roller and these engage the sheets and hold them automatically against the roller. (*J.S.G.T.*)

Process for toughening glass sheets. BAYERISCHE SPIEGELGLASFABRIKEN BECHMANN-KUPFER A.-G. Ger. 576,218, April 20, 1933. The tempering process is carried out by blowing in the cooling air from a series of relatively narrow jets set concentrically in larger apertures which communicate with a suction trunk so that the air is removed from the surface of the glass and the cooling is accelerated. (*J.S.G.T.*)

Production of barium borosilicate glasses. Fluxes. E. HEINZ. Ger. 580,596, June 29, 1933. Colorless or colored silicate glasses containing barium and boron are produced by introducing these constituents into the batch as powdered barium borosilicates. (*J.S.G.T.*)

Production of compound glass. PILKINGTON BROS., LTD. Ger. 576,729, May 4, 1933. (1) Two sheets of glass of different breadths are united while soft so that the edges of the broader overlap those of the smaller. (2) Wire reinforcement is inserted between the sheets leaving the edges free. (*J.S.G.T.*)

Production, filling, and sealing of ampoules. BORNKESSEL BRENNER UND GLASMASCHINEN G. M. B. H. Ger. 579,941, June 15, 1933. A length of glass tube sealed at its lower end and sufficient to make several ampoules is held vertically in a machine which delivers a filling charge in the tube and then seals it off above the level of the charge to form a sealed ampoule and another sealed bottom on the stock length of tube, the process being repeated until the latter is used up. (*J.S.G.T.*)

Production of glass threads. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 579,689, June 15, 1933; addition to Ger. 539,738 (*Ceram. Abs.*, **12** [4], 152 (1933)).—The parent specification is modified in that an air blast is directed roughly perpendicular to the plane of rotation of the centrifuge disk, so forcing the glass threads detached from the latter down below. (*J.S.G.T.*)

Production of multi-hue glass. GLASHÜTTENWERKE VORM. I. SCHREIBER & NEFFEN. Ger. 581,134, July 6, 1933. Glass which gives various tints to objects viewed through it according to the angle of view is produced by flashing glass of one transparent color with another of different color such that the glass of the outer layer is wholly or partly transparent to the color transmitted by the inner one, but the inner one is not, or only slightly, transparent to that transmitted by the outer layer. (*J.S.G.T.*)

Production of rod and tube. COMPAGNIE DES LAMPES. Ger. 579,587, June 15, 1933. Glass is allowed to flow out from a suitably shaped orifice in the bottom of a container and a rotatory motion about its central axis is imparted to it by maintaining a temperature difference between opposite sides of the orifice. (*J.S.G.T.*)

Protecting refractories in tank furnaces. Rumanian 21,423, Jan. 19, 1933; *Glashutte*, **63** [46], 780–81 (1393).—A detailed description is given of rotating refractory-protecting bodies. Illustrated. M.V.K.

Protective lacquers for silvered surfaces. E. MEIER. Ger. 576,344, April 27, 1933. Cuprous oxide is added to the lacquer used to "back" the silvered mirror surface. (*J.S.G.T.*)

Rolling glass sheets without wave. Y. BRANCART. Ger. 581,085, July 6, 1933. In a process for rolling glass sheets in which the peripheral speed of the roll is greater than that of the displacement of its axis relative to the table, the roll rotates about trunnions fixed above the table without its generator being in direct contact with the latter. (*J.S.G.T.*)

Tool for scratching glass in cracking off machines. H. KRATZ. Ger. 576,087, April 20, 1933. Means are provided on the holder of the cutting tool for setting the latter against an adjustable stop so that it can be removed and replaced in the correct position. (*J.S.G.T.*)

Structural Clay Products

Chipping machines for grooves in brickwork. EUGEN HEIMBUCHER. *Eng. Progress*, **15** [3], 51–52 (1934).—A machine for cutting smooth grooves in brickwork is described and illustrated. The width of the groove is determined by the number of cutting blades attached to the rotor and the depth by an adjustable stop. Grooves 2.5 by 2.5 cm. can be cut. Illustrated. J.L.G.

Effect of firing on the coloring of clay. ANON. *Rev. mat. constr. trav. pub.*, No. 292, p. 17*B* (1934).—Studies of Zimmermann showed that the admixture of 20% chalk to the clay mix and firing in a reducing atmosphere color the products a fine yellow without cracking or damaging them; the defects occur when the products are fired in an oxidizing atmosphere. M.V.K.

Firing color of brick. A. O. *Lerindustrien*, No. 24, pp. 141–44 (1933); abstracted in *Tonind.-Ztg.*, **58** [25], 323 (1934).—Precautions to be taken when manufacturing red and yellow brick are discussed. M.V.K.

Manufacture of paving clinker from raw materials of Kiev. RASIN. *Ukrainsky Silikaty*, No. 10, pp. 281–85 (1932). S.I.P.

Sewer-pipe materials. WILHELM SEEGERT. *Gesundh.-Ing.*, **57** [13], 166–67 (1934).—S. discusses cement, concrete, and clay sewer pipe, pointing out the particular features of each. E.J.V.

Use of clay shales for building brick manufacture. O. V. TERESHTCHENKO AND M. G. DYGALO. *Ukrainsky Silikaty*, No. 6–7, pp. 129–32 (1932).—Of the two methods

in use for common red building brick manufacture (plastic and dry-pressing) the latter is preferable. For dry-pressed brick manufacture the following operations have been used: crushing, grinding, sieving, moistening, pressing, and firing; sieving through 36-mesh/cm.^{2}; moisture is 6%; pressure 259 kg./cm.^{2}; firing at 1100°C. The results of testing are as follows: size 270 x 135 x 55 cm.; weight of "green" brick 5.32 kg.; weight of fired brick 4.74 kg.; water absorption 8.04%; average crushing strength of air-dried specimens 136 kg./cm.^{2}; total shrinkage 2.2%; volume weight 2. S.I.P.

BOOK REVIEW

What Are New Building Materials? V. P. NEKRASSOV. State Sci. Tech. Pub. House of Building Industry and Ship Building, Moscow and Leningrad, 1933. 40 pp. Price 40 kopecks. This small popular brochure discusses briefly the following questions: (1) why materials used during hundreds and thousands of years have ceased to satisfy us; (2) how and by what metals Portland cement, wood, lime, common red building brick, and quarry and natural stones may be replaced; (3) what kind of chief building materials help to decrease labor, fuel, and transport and to increase labor efficiency, mechanization, and industrialization of building, and (4) new roofing materials and sewer and water pipes. S. I. PERKAL

PATENTS

Apparatus for dumping brick and molds. W. J. DONNELLY. U. S. 1,956,192, April 24, 1934.

Insulated and waterproof masonry wall construction. W. L. RAU. U. S. 1,959,176, May 15, 1934.

Method for continuously decorating brick, tile, etc. JOHN RAMSAY. U. S. 1,958,837, May 15, 1934. The method of decorating brick comprises extruding a column of clay material through a die, treating the clay with a coagulating reagent, and applying to the column a liquid veneer.

Method of making building units. E. M. WYATT AND KEMPER SLIDELL (American Face Brick Research Corp.). U. S. 1,956,607, May 1, 1934. The process of producing a building block consists in manipulating argillaceous material while in the plastic state to form separated particles, accumulating the particles into a porous mass of adhering particles without destroying the interstices between the particles, and firing the mass to form a porous block.

Refractories

Acid lining for melting nonferrous metals in high frequency furnaces. J. A. KLYUTSCHAREV AND S. A. LÖWENSTEIN. *Feuerfest*, **9** [12], 157–59 (1933).—Experiments on the manufacture of crucibles for melting nonferrous metals are described. It was found that (1) Luga sand is a suitable material for the manufacture of acid lining; (2) the addition of coarse-grained ground quartz is necessary to increase the thermal resistance of the mix and its density when ramming; this factor is without effect on chemical resistance; (3) the addition of powdered glass is indispensable. The composition of the crucible mix is Chassov-Yar clay 12%, natural sand 30%, glass 15%, ground sand 33%, and ground quartz 10%. The results with crucibles of this composition were satisfactory. M.V.K.

Adaptability tests of refractory brick for industrial furnaces. A. MÖSER. *Tonind.-Ztg.*, **58** [23], 288–90 (1934).—Two cases of the destruction of refractory brick by coal ash are described, and the value of coal investigation for determining the reason of the attack is dealt with. Because the crucible testing method failed in consequence of the weakness of attack and the neutralizing of slag, the method of Ising (*Ceram. Abs.*, **12** [12], 423 (1933)) for testing refractories was applied, but without results. The reason for its failure is discussed. Good results were obtained in a short time by combining the methods of Ising and Hartmann. M.V.K.

Ceramics of highly refractory materials. I. The forms of ZnO. OTTO RUFF AND FRITZ EBERT. *Z. anorg. allgem. Chem.*, **180** [1], 19–41 (1929). **II. The system ZrO_2–CaO.** OTTO RUFF, FRITZ EBERT, AND EDWARD STEPHAN. *Ibid.*, [2], 215–24 (1929). **III. The system ZrO_2–ThO_2.** OTTO RUFF, FRITZ EBERT, AND HANS WOITINEK. *Ibid.*, [3], 252–56 (1929). **IV. The system ZrO_2–BeO.** OTTO RUFF, FRITZ EBERT, AND EDWARD STEPHAN. *Ibid.*, **185** [1–2], 221–24 (1929). **V. The ternary systems ZrO_2–ThO_2–CaO, ZrO_2–ThO_2–MgO, ZrO_2–BeO–CaO, ZrO_2–BeO–CeO_2.** OTTO RUFF, FRITZ EBERT, AND WILHELM LOERPABEL. *Ibid.*, **207** [3], 308–12 (1932). **VI. The system ZrO_2–MgO.** FRITZ EBERT AND ERNST COHN. *Ibid.*, **213** [4], 321–22 (1933).—From X-ray and analytical studies the equilibrium diagram of the system was solved. The compound $MgZrO_3$ reported by von Wartenberg was not found. There exists in the system a solid solution series with the end member $Mg_2Zr_3O_8$. **VII. The binary systems MgO–CaO, MgO–BeO, CaO–BeO.** OTTO RUFF, FRITZ EBERT, AND URSULA KRAWCZYNSKI. *Ibid.*, [4], 333–35 (1933).—The eutectic compositions and melting temperatures in these systems were newly determined and reported. L.T.B.

Chlor-resistant silica brick for the production of aluminium chloride. P. P. BUDNIKOFF. *Sprechsaal*, **67** [10], 135–36 (1934).—When producing aluminium chloride by chlorination of aluminous silicates, high-quality silica may be used with good results as a chlor-resistant refractory for the furnace. The chief requirements for chlor-resistant brick are (1) not less than 96.0% SiO_2, not more than 1.5% Al_2O_3, not over 2.3% CaO; (2) specific gravity not over 2.36; (3) resistance to pressure at least 150 kg./sq. cm.; (4) volume porosity not over 22%; (5) with a repeated firing to 1500 and a duration of 1.5 hr., the permanent thermal expansion must not exceed 0.5%; and (6) the thin sections of silica must show a complete absence of quartz and the presence of a web of developed tridymite crystals. A good mortar is composed of 60% quartz, 30% crushed fired silica, and 10% plastic refractory clay; its alumina content must not be over 6.5%. Illustrated. M.V.K.

Contributions to the knowledge of materials with highest melting points. CURT AGTE. *Physik. Ber.*, **13** [5], 520 (1932).—The melting point of a number of carbides was determined; the method is described. The values found are as follows:

ZrC	3805°C abs. ± 125	TaC	4150°C abs. ± 150
NbC	3770 " " ± 125	W_2C	3130 " " ± 50
Mo_2C	2960 " " ± 50	WC	3140 " " ± 50
MoC	2965 " " ± 50	TiC	3410 " " ± 90
HfC	4160 " " ± 150	Re (metal)	3440 " " ± 60

See also C. Agte and H. Alterthum, *Ceram. Abs.*, **11** [8], 457 (1932). M.H.

Dimensions of grog brick. BENINGA. *Tonind.-Ztg.*, **58** [19], 239–40 (1934).—The effect of drying, molding, firing, and the compositions of crushed grog, bonding clay, and thinning agents on the dimensions of grog brick are discussed. M.V.K.

Evaporation technique for highly refractory substances. H. M. O'BRYAN. *Rev. Sci. Instruments*, **5** [3], 125–26 (1934).—Boron, carbon, boron carbide, silicon carbide, fused quartz, and other substances have been evaporated in vacuum from a crucible heated by bombardment with electrons at 4000 volts from a tungsten filament. A small pure graphite crucible was heated to its melting point, about 3500°C, by 100 milliamperes of electron current. Most elements will alloy with a tantalum or molybdenum crucible so a graphite cup is usually preferable. Low-melting point substances which would easily alloy with a tungsten filament can be easily handled by this method, which has been used in the preparation of X-ray target surfaces, small mirrors, and absorbing films. A.K.

German specification for glass tank blocks. ANON. *Keram. Rund.*, **41** [49], 653 (1933); *Glashütte*, **63** [50], 850 (1933).—The proposed standard specifications refer only to blocks manufactured in the usual way, especially by hand. The alumina content is not specified, but a tolerance of ±2% is allowed on whatever alumina content is prescribed by the user. The iron-oxide content is fixed as 2.5% with a variation of +0.5%. The minimum cone melting point is 28; total pore volume, 29% maximum; volume constancy on heating for 4 hr. at 1400°, ±1.5% in length; cold resistance to pressure, 120 kg./sq.cm. M.V.K.

Granulometric composition of grog for the densest glass-refractories manufacture. G. Y. ZHUKOVSKY. *Ukrainsky Silikaty*, No. 6–7, pp. 133–35 (1932).—For control in sieving it is not necessary to have a great number of fractions; three will be enough: (1) fine < 0.25 mm., (2) average from 0.25 to 2 mm., and (3) coarse > 2 mm. For those glass refractories which undergo the action of high temperatures and are in direct contact with molten glass, the size of grains should be finer and the most suitable fractions are as follows: (1) 0.5 mm., (2) 0.5 to 1.5 mm., and (3) 1.5 to 2 mm. A diagram is given with 4 curves: Fuller for rounded grains, Litzov for acute-angled grains, Rieke and Gieth for slightly rounded grains, and Rieke and Gieth for grains 0.2 mm. These curves correspond to the densest masses. A table is given for calculating the quantity of a plastic bond clay necessary to cover the surface of grog grains and in such a way to establish the proper ratio of grog to clay. Twenty-eight literature sources are cited. S.I.P.

Heat conductivity of insulating materials at low temperatures. E. RAISCH AND W. WEYH. *Z. ges. Kälte-Ind.*, **39** [6], 123–25 (1932); abstracted in *Physik. Ber.*, **13** [19], 1733 (1932). M.H.

Highly refractory zircon refractories. P. P. BUDNIKOFF. *Domez*, **5** [1], 47–48 (1933).—The use of ZrO_2 (melting at over 2000°) for highly refractory purposes has become possible, first, with the use of suitable bonding agents. Zircon crucibles and brick are distinguished by their high thermal stability and great resistance to acid slag and alkalis when using an appropriate bond. Hydrofluoric acid and "bisulfate" and iron silicate at over 2000° attack zircon brick. The temperature of the softening under load of zircon materials is higher than that of any other refractories. Its hardness (7.5) is only little lower than that of silicon carbide. The brittleness of zircon products is considerably reduced by adding lime or magnesia to the mix. Two zircon mixes are given: (1) 75% ground zircon ore (100-mesh/sq. cm.), 23% ground zircon (10-mesh/sq. cm.), 2% slaked lime, and 3% water glass (38 Bé); (2) 100 kg. ground zircon ore, 0.5 kg. dextrin, and 0.25 kg. boric acid. The zircon ore is fired and then ground in the second mix. The brick are fired to 1900° for 10 hr. The chemical composition of a zircon product showed 59.8% ZrO_2, 27.7 SiO_2, 9.2 Fe_2O_3, 0.1 CaO, 1.1 TiO_2, and traces of MgO. Small amounts of magnesia lower the porosity of zircon products when fired below 2000°; for temperatures over 2000°, thorium oxide is more efficient. Additions of SiO_2 and beryllium are without effect. Starch or molasses, 1%, is used as a bonding agent. Details of the separate manufacturing processes and firing are given. The zircon ore used contained about 69% ZrO_2 and 26 SiO_2. For obtaining dense products, an addition of 1% Al_2O_3 is the best, provided the firing temperature of the products reaches 2000°. A table with comparative data for grog, Dinas, silicon carbides, and zircon brick is given. M.V.K.

Magnesite brick industry. R. V. WIDEMANN. *Céramique*, **36**, 284–89 (1933).—W. reviews the magnesite brick industry, including raw materials, fabrication, and uses and production in various countries. M.H.B.

Measurement of the degree of blunting the corners and edges in refractory materials. V. LEBEDEV. *Ukrainsky Silikaty*, No. 6–7, pp. 141–46 (1932).—A detailed description is given of two instruments designed by L., one for measuring the blunting (breaking off) of corners and the other for the edges. A project of a standard method for these measurements is outlined. Illustrated. S.I.P.

Metal-cased magnesite brick. S. I. PERKAL. *Ukrainsky Silikaty*, No. 6–7, pp. 195–97 (1932).—Data on the manufacture, uses, and properties of these brick (patent McCallum) are given. S.I.P.

A metallurgist looks at ceramics. H. W. GILLETT. *Bull. Amer. Ceram. Soc.*, **13** [5], 117–22 (1934).

Method of manufacture of highly grogged refractories. L. LITINSKY. *Ukrainsky Silikaty*, No. 3, pp. 50–60 (1932).—The existing methods of grog refractories manufacture in Europe are compared. In Scheidhauer and Giessing's method 90 to 95% of grog is mixed with 10 to 5% of bonding clay which has been liquefied with an electrolite, *e.g.*, liquid glass or soda. The water content of the nonplastic mix is 6 to 9% of the weight of the whole mix. It is tamped by hand or by machine. The research work of

Russian investigators and Russian and foreign patent literature on this subject are reviewed. The eight advantages of this method are enumerated. S.I.P.

Microscopical investigation of quartzites, Dinas, and grog. V. G. Popov. *Ukrainsky Silikaty*, No. 1–2, pp. 34–37 (1932).—Eleven figures of thin sections and their descriptions are given. S.I.P.

New refractory material for Siemens-Martin and electric steel furnaces. E. Reitler. *Feuerungstechnik*, **22** [3], 29–30 (1934).—A silica brick with a high refractoriness, insensitiveness to temperature changes, and resistance to attack of slag present in furnace gases is used in Siemens-Martin furnaces in Spain. The raw material is composed chiefly of silica with little iron oxide and is similar to agate, hence the name "agate brick." The mineral is treated to remove impurities, and the agate brick are pressed at 300 atmospheres pressure and fired at 1460°. A table showing the comparative properties of agate and silica brick I is given. With an almost identical composition and equal total pore space, the melting point of agate brick is higher than that of silica brick and its resistance to pressure under load at high temperature is much higher than that of silica brick. The specific gravity of agate brick is lower than that of silica brick which indicates that the former contain more tridymite than the latter. It is confirmed by the fact that agate brick expand less than silica brick. Comparative tests with silica and agate brick are described. M.V.K.

Note on improvement of the quality of refractory materials. A. A. Vurgaft. *Ukrainsky Silikaty*, No. 1–2, pp. 40–42 (1932).—Ten points on how to increase the quality of refractories are indicated. S.I.P.

Physical and chemical phenomena in firing brick and tile. Karel Hinais. *Stavivo*, p. 128 (1933).—Czechoslovakian clays contain 23.5 to 86.5% kaolinite assuming that all the Al_2O_3 is present in the form of kaolinite. They contain no free silica, 55.2 to 68.2% clay substance, 1.2 to 11.5% iron compounds, 0.5 to 30.0% lime, and 0.6 to 8.5% magnesia compounds. R.B.

Progress in crucible melting. G. S. Watson. *Metal Ind.* [London], **44** [2], 66–67 (1934).—External wear of crucibles in solid fuel furnaces is chiefly caused by the reaction between the slaggy ash content of the fuel and the crucible materials, while internal wear is mainly due to the erosion of the crucible by metal oxides or by fluxes. It has been found that the external and internal wear may be reduced by the addition to the crucible mixings of certain of the inert refractory materials now manufactured in the electric-arc furnace. The addition of graphite to fire clay materially adds to its thermal conductivity. A study of the physical characteristics of the graphite particles has disclosed the importance of the correct orientation of the flake in the wall of the pot. It was found that the structure which gives greatest conductivity also provides the greatest resistance to external erosion by fuel slag. M.V.K.

Reactions between solids in the absence of a liquid phase. Nelson W. Taylor. *Jour. Amer. Ceram. Soc.*, **17** [6], 155–63 (1934).

Refractories and sands for the nonferrous industries. Alfred B. Searle. *Metal Ind.* [London], **44** [2], 67–69 (1934).—Two properties stand out much more prominently than all others when refractories are considered, the proportion of fusible matter and the grain size of the brick; the nature and amount of the impurities are of much greater relative importance than the fire clay, silica, or magnesite which form the largest constituents, while the properties due to the proportions of grains of various sizes constitute the chief of the physical factors affecting durability, refractoriness, permeability, etc. Another important factor is the need for the greatest possible accuracy in the size and shape of the brick. The other important properties such as (1) refractoriness under load, (2) after-contraction, (3) water absorption or porosity, (4) specific gravity, (5) resistance to slag and to spalling, and (6) thermal conductivity are discussed together with special refractories, effect of design and mode of working, electric furnaces, oil-fired furnaces, crucibles, general brickwork, and channel brick. The zinc industry demands brick with a great resistance to abrasion and a smooth and dense surface. Brick resistant to sulfurous vapors are required for roasting furnaces. In the copper industry silica brick are preferred. The increasing use of Bessemer converters and electric furnaces is showing the importance of a basic lining. For brass and other alloys, use is made of grog in the fire brick. A hearth of chromite over magnesite has been found to be specially resistant to antimony oxides and other white metal residues. Nickel and its alloys do not call for highly refractory materials. Aluminum and its alloys are chiefly melted in electric furnaces and do not require special refractories. For lead and antimony alloys, magnesite is preferred. See also *Ceram. Abs.*, **12** [10–11], 379 (1933). M.V.K.

Refractory materials for blast furnaces. Alfred B. Searle. *Metallurgia*, **9** [51], 85–87 (1934). M.V.K.

Relationship between water permeability and structure of refractory materials. Otto Bartsch. *Keram. Rund.*, **41** [45], 595–98 (1933); abstracted in *Chim. & ind.*, **31** [3], 608 (1934); for abstract see *Ceram. Abs.*, **13** [4], 90 (1934). M.V.K.

Re-pressing grog articles on Berger's stamp presses. Z. N. Izrailevsky. *Ukrainsky Silikaty*, No. 1–2, pp. 38–40 (1932). S.I.P.

Results of testing "black" Dinas in open-hearth furnaces. R. L. Pevsner. *Ukrainsky Silikaty*, No. 6–7, pp. 150–56 (1932).—The tested Dinas has the following properties: P.C.E. 1680°C, specific gravity 2.40, volume weight 1.88, apparent porosity 21.6%, water absorption 11.2%, mechanical strength 228 to 310 kg./cm.^{2}, deformation under load 1590°C. The crown of a 20 T. open-hearth furnace was lined with three kinds of Dinas: (1) 1/3 black Dinas, (2) 2/3 ordinary white Dinas made from the same quartzites as the black, and (3) between these, a few brick of German origin ("Stellawerk"). The furnace for high-grade steels (stainless, etc.) was dried for 4 days. The following conclusions were drawn: (1) black Dinas, *i.e.*, containing 1% pit slags (Schweszofenschlacke) showed better service than the ordinary white Dinas; (2) black Dinas served 763 heats against 413 heats of the white Dinas and 615 heats of the Dinas from the Stellawerk; (3) the idea of adding pit or open-hearth slags to the Dinas batch was suggested long ago by Groum-Grjimailo and has been applied in many plants; the tests showed that the quality of Dinas is increased by this addition; (4) by using black Dinas in open-hearth furnaces it is possible to reduce the expenditure of refractory materials; (5) the method of

manufacture of black Dinas in no way differs from the manufacture of ordinary white Dinas and does not require additional equipment; (6) open-hearth and other slags are found in great quantities in metallurgical plants and it is easy to get them; (7) the cost of manufacture of black Dinas is the same as for the ordinary kind, but its service life is longer; (8) to obtain black Dinas of good quality it is necessary to distribute the slags uniformly through the whole batch; (9) in the drying and heating processes and in putting an open-hearth furnace lined with black Dinas into operation it is necessary to take definite precautions in the increase of temperature; (10) black Dinas can be manufactured not only from so-called amorphous quartzites, but also from slow-conversion crystalline quartzites. S.I.P.

Sagger mass preparation by the slip-casting process. D. CHOKOLOV. *Ukrainsky Silikaty*, No. 3, pp. 73–74 (1932). S.I.P.

Silica refractories give double service. P. P. BUDNIKOFF. *Ceram. Age*, **22** [5], 130–31 (1933).—The experimental production of "black Dinas," a form of silica refractory in which the quartz has largely been converted to tridymite, is described in detail. Conversion to tridymite is effected by the addition of iron-bearing mineralizers and a reducing material such as coke dust or charcoal. Open-hearth furnace slag, Thomas and weld slags, and blast-furnace dust, obtained from the smelting of cast iron, are used as mineralizers. The quantity of iron-containing mineralizer should not exceed 2 to 3% of the weight of dry quartzite. A greater quantity of mineralizer does not promote additional conversion into tridymite under the same firing conditions, but does lower refractoriness, porosity, and softening point under load at high temperatures. Grains of metallic iron are removed from the ground mineralizer by means of a magnet, as such particles act as fusing centers which result in fused brick. The mineralizer is added to the dry quartzite powder in a finely ground state. The customary lime solution is not added until the mineralizer has been thoroughly dry-mixed with the quartzite. To secure a reducing atmosphere within the brick and to give it the normal porosity, about 1.5% of ground coke or charcoal is added. The reducing atmosphere is necessary for the formation of the ferrous-oxide glass in which the quartz dissolves relatively easily and in which the crystallized tridymite remains undissolved. The normal porosity imparts the necessary resistance to spalling. To increase the green strength, 1/8 of 1% of organic binder is added. One-half of 1% of lime is also added. The granulometric composition of the mixture must be such that the grains vary from a fine flour up to grains of 5 mm. in diameter. It is sufficient if not more than 50% of the grains will pass through a 1.0 mm.-mesh sieve. The firing of black Dinas brick is carried out under conditions comparable to those employed with ordinary silica brick. It is especially important to employ a reducing atmosphere during the main firing, to fire at a high temperature (1460 to 1480°C), and to hold the ware at a high temperature. The duration of soaking depends upon the quality of the raw material used. The cooling must be carried out carefully, especially at temperatures below 600°C. An open-hearth furnace unit built from first class tridymite brick made thus is claimed to withstand approximately 600 meltings. F.G.H.

Silicon carbide and silicon carbide refractories. S. I. PERKAL. *Ukrainsky Silikaty*, No. 8, pp. 212–21 (1932).—The development of silicon carbide manufacture from the time of Acheson with the electric furnace of few amperes until the present time with the furnaces of 100, 764, 1500, and 2250 kw. is described. The properties of silicon carbide and the manufacture, properties, and numerous uses of bonded and recrystallized silicon carbide superrefractories are described. S.I.P.

Softening temperature of ordinary silicoaluminous refractory products. II. MARCEL LÉPINGLE. *Verre & Silicates Ind.*, **5** [5], 82–85; [6], 103–106 (1934).—The properties of silicoaluminous refractory products manufactured in England and Belgium are discussed in detail. Tables and diagrams illustrate the paper. For Part I see *Ceram. Abs.*, **13** [6], 152 (1934). M.V.K.

Studies of refractory minerals. No. 18. Cyanite. ANON. *Refrac. Jour.*, **10** [4], 166 (1934).—A description of the occurrence and properties of cyanite is given. For No. 17 see *Ceram. Abs.*, **13** [6], 152 (1934). A.J.M.

Thermal conductivity of Acheson graphite. A. P. CRARY. *Physics*, **4** [9], 332–33 (1933).—Thermal conductivity of Acheson graphite is reported for the temperature range −150 to +700°C. Cylindrical blocks of graphite were placed above and below a flat electric heater and lateral losses balanced out by auxiliary coils wound on the surface of the sample. The results show a continued decrease in thermal conductivity with temperature over the entire range. The law, $k/aC = A/T + B$, proposed by Bidwell for certain other materials, is found to hold accurately for graphite.

Thermal conductivity of refractories. GORDON B. WILKES. *Jour. Amer. Ceram. Soc.*, **17** [6], 173–77 (1934).

BOOK REVIEWS

Dinas from Crystalline Quartzites. I. S. SMELJANSKY. Ukrainian Sci. Research Inst. of Refractory and Acid-Resisting Materials. State-Sci. Tech. Pub. House of Ukraine, Kharkov, and Kiev, 1933. 40 pp., 17 figs. Price 1 R, 50 kopecks. This work is a continuation of a previous one (*Ceram. Abs.*, **11** [8], 456 (1932)) and has been undertaken to prepare Dinas from crystalline quartzites in plant scale and to test the product in open-hearth furnaces. From the 22 batches the following were chosen:

No. of batches	Quartzites A (%)	River sand (%)	CaO (%)	Molasses (%)	Pit slags (%)	Charcoal (%)
1	100		2	0.25		
13	75	25	1.5	0.25	1.5	1.5
21	100		1.5	0.25	1.5	1.5

The chemical composition of the components is as follows:

	Quartzite A (%)	River sand (%)	Pit slag (%)
Fe			43.68
SiO_2	97.19	97.8	34.10
Al_2O_3	0.79	0.52	1.33
Fe_2O_3	0.76	0.62	
CaO	0.78	0.63	1.54
P_2O_5			0.12
MgO	0.06		0.6
MnO			0.27

Ignition loss 0.44
P.C.E. Seger cone 34 (1750°C)

The granulometric composition is as follows:

Quartzite grains	(%)
From 7–5 mm.	3
" 5–3 mm.	17
" 3–1 mm.	25
" 1–0.5 mm.	11
Less than 0.5 mm.	44

Pit slags through a sieve 900-mesh/cm.²
Charcoal through a sieve with apertures 1 mm.
Sand through a sieve with apertures 1 mm.
Moisture of the mixture moistened with lime milk is 8.5% of the weight of the dry powder.
The highest temperature of firing was Seger cone 16 (1460°C).

On the basis of testing the silica brick for the laboratory and service life in crowns and heads of 25, 50, and 100 T. open-hearth furnaces, the following conclusions were drawn: (1) The investigated crystalline quartzites are slowly transformed during firing. They are suitable for the manufacture of first-grade silica brick. If the conditions of manufacture are properly chosen, *i.e.*, by a correct granulometric composition of the batch, good treatment of the mass in a wet-edge mill, careful molding, and proper firing, only high-grade silica brick are obtained from these quartzites with the usual addition of 2% lime. (2) The optimum granulometric composition of the mass should be as follows:

Grains from	(%)
5–3 mm.	6–8
3–1 mm.	20–25
1–1.5 mm.	15–20
0.5 mm.	50–55

To increase the per cent of yield by firing silica brick without flaws and cracks it is necessary to prevent the introduction into the mass of grains greater than 5 mm. It is necessary to introduce into the batch 15 to 25% of broken silica brick when Dinas of great size is manufactured. Special attention should be given to the good quality of lime. Lime milk should not contain particles of unslaked lime. There should be about 2 to 2.5% of free lime in the mass. The green brick when introduced into the furnace should not contain more than 1% moisture. (3) The addition of 0.25 to 0.125% molasses increases the mechanical strength of the green brick and lowers the waste. (4) The introduction in the Dinas batch of 25% quartz sand considerably eases the molding of the Dinas green brick and does not lower the quality of Dinas. (5) An increased moisture of the mass improves the quality of Dinas considerably. The amount of moisture is limited by the possibility of the green brick losing their regular shape. (6) Pit slags ("welding" slags) are undoubtedly excellent mineralizers, promoting a more definite crystallization in Dinas of lanceolate veins of tridymite; they should be finely ground and carefully mixed with the quartzite powder. If the last indication is not taken into consideration the slags promote the formation of places (lots) with a lowered melting temperature. The optimum quantity of this addition is 1.5 to 2%. With the addition of pit slags there should be introduced into the batch about 1.5% coke dust or, still better, the same quantity of powdered charcoal as a reducing agent and to increase the porosity and thermal strength of Dinas. Dinas which contains 1.5% pit slags and 1.5% charcoal *i.e.*, the so-called black Dinas (often called brown Dinas), has a higher thermal strength than the ordinary white Dinas in firing and cooling time (during manufacture) and in its service in open-hearth furnaces. The disadvantage of black Dinas at the temperatures in open-hearth furnaces is its somewhat decreased refractoriness. (7) For firing high-grade Dinas from the investigated crystalline quartzites it is necessary to bring the firing temperature to Seger cone 16 and maintain this temperature about 16 hours. There is no necessity of raising the firing temperature higher than Seger cone 16 and this is not recommended because of the danger of formation of sharp flame and increase in yield of Dinas with flaws. (8) (*a*) Dinas made from batch No. 1 is somewhat more stable than the ordinary Dinas from amorphous quartzites; (*b*) Dinas from batch No. 21, used in the crowns of open-hearth furnaces, is nearly as stable as Dinas of batch No. 1 and plant Dinas from amorphous quartzites, but in the heads of open-hearth furnaces it is somewhat less stable because of its decreased refractoriness; (*c*) Dinas from batch No. 13 used in crowns of open-hearth furnaces has the same behavior as Dinas made from batch No. 21.

S. I. PERKAL

Dinas Manufacture (Refractory Materials from Quartz Rocks). 3rd ed., enlarged and revised. I. S. SMELJANSKY. State Sci. Tech. Pub. House of Building Industry and Shipbuilding, Moscow, 1933. 124 pp. Price 80 kopecks. The subject of this brochure is outlined under the following headings: (1) history of Dinas manufacture, (2) raw materials, (3) preparation of quartzites for the manufacture, (4) molding, (5) firing, (6) flow sheet of Dinas manufacture, (7) field of Dinas application, and (8) specifications. This is the only brochure in U. S. S. R. dealing with silica brick manufacture in its general aspects.

S. I. PERKAL

Recuperators for Heating Furnaces, Calculations and Constructions. I. M. LEMLEKH. State Energetical Pub. House, Leningrad, 1933. 92 pp. Price 2 R. This is a valuable book for those interested in design, calculation, and building of recuperators. S. I. PERKAL

Technical Control of Grog Refractories Manufacture. R. L. PEVSNER. State Sci. Tech. Pub. House of Building Industry and Shipbuilding, Moscow, 1933. 88 pp. Price 1.25 R. General introductory notes on the quality of refractories and the value of control in all stages of their manufacture are followed by instruction on the organization of the division of technical control in refractory plants and by short descriptions of methods for testing raw materials and semifinished and finished products. The following official All-Union Standards are appended: (1) methods of chemical analysis of clay and quartz building materials, (2) grog brick, (3) grog refractories, (4) methods of testing refractory materials at high temperatures, (5) estimation of refractoriness, (6) estimation of deformation under load at high temperatures, and (7) method of determination of the thermal stability of ceramic refractory materials. A reference literature list is given.

S. I. PERKAL

BOOK

Annual Report of Scientific and Industrial Research. Published by H. M. Stationery Office. 3s. Reviewed

in *Metal Ind.* [London], **44** [4], 113–15 (1934).—The work of the British Refractories Research Association dealing with the shrinkage of clays and grading of materials is discussed. M.V.K.

PATENTS

Furnace construction. R. C. DENNY (M. H. Detrick Co.). U. S. 1,957,098, May 1, 1934.

Manufacture of alumina. ARTHUR FLEISCHER (KALUNITE CO.). U. S. 1,957,767 and 1,957,768, May 8, 1934.

Manufacture of alumina hydrate. ARTHUR FLEISCHER (Kalunite Co.). U. S. 1,957,766, May 8, 1934.

Method of making refractories. W. M. CHARMAN AND P. R. WARD (Ferro Engineering Co.). U. S. 1,956,894, May 1, 1934. The method of making refractories consists in thoroughly commingling sodium silicate solution and an aggregate chemically inert to sodium silicate, compacting the mixture, and firing it in an atmosphere substantially free from carbon monoxide and carbon dioxide at a temperature no greater than 500°F.

Refractory. W. M. CHARMAN AND P. R. WARD (Ferro Engineering Co.). U. S. 1,956,895, May 1, 1934. A refractory comprises the following ingredients uniformly distributed throughout its mass in approximately the proportions by weight stated: 1 to 9% dry sodium silicate equivalent, 0.5 to 5% zinc oxide, and approximately 85 to 98% an aggregate chemically inert to sodium silicate.

Removable furnace refractory. ALDO MACCHI (General Electric Co.). U. S. 1,957,220, May 1, 1934.

Manufacture of hollow objects from fused refractory materials. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Brit. 409,165, May 2, 1934.

Manufacture of refractory articles, linings, etc. G. WILSON AND TURNER & NEWALL, LTD. Brit. 408,386, April 18, 1934.

Method of producing compounds of aluminium and the rarer elements from bauxite. E. L. RINMAN. Brit. 408,710, April 25, 1934.

Refractory materials and method of making. G. E. SEIL. Brit. 409,130, May 2, 1934.

Terra Cotta

Blistering and crawling of glazes caused by underslips. H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **17** [6], 182–84 (1934).

Weather stability of building materials. ANNEMARLE SCHMÖLZER. *Tonind.-Ztg.*, **58** [24], 303–304; [25], 318–19 (1934).—After discussing the reasons for the weathering of building materials, methods used for testing weather stability are enumerated, including (1) microscopic and chemical analyses; (2) determination of porosity, water absorption, and coefficient of saturation; (3) determination of the degree of absorption, water permeability, and capillarity; (4) evaporation of moisture; (5) changes in volume when moistened; (6) effect of salt crystallization; (7) action of acids and acid gases; (8) determination of frost stability; (9) wearing tests, (*a*) with abrasive disks and (*b*) sandblast; (10) determination of strength, (*a*) resistance to pressure and (*b*) tensile strength; and (11) determination of the inclination to form spots. M.V.K.

White Wares

Automatic glazing in the ceramic industry. H. V. SCHWEITZER. *Bull. Amer. Ceram. Soc.*, **13** [5], 123–26 (1934).

High-tension insulators need tests before reuse. ANON. *Elec. World*, **103** [10], 366 (1934).—To avoid premature trouble from the reuse of high-voltage (10 kv. and more) insulators, the New England Power Assn. has set up standards covering the testing and handling of salvaged insulators which are given in detail. Failures of insulators in service are classified under three general headings, (*a*) electrical stresses, (*b*) internal mechanical stresses due to manner of assembly, and (*c*) external mechanical loadings. A.K.

Improving the quality of tile through pretreatment and mixing of clay. MAX PULFRICH. *Tonind.-Ztg.*, **58** [20], 250–52 (1934).—The exact knowledge of materials used is the foundation for improving the quality of ware. The chief and typical properties of various argillaceous raw materials are discussed. Tables give (1) the chief kinds of clays, their properties, and use; (2) mineral impurities present in clay which require a special treatment and their effect on the ware; and (3) details of working and preparing the raw mix. Practical examples are given. M.V.K.

Manufacture of grog saggers from low-grade clays ("balyk") of Chassov-Yar. I. I. KUZMENKO, M. M. VOLOSHTCHENKO, AND A. D. DERKATCH. *Ukrainsky Silikaty*, No. 9, pp. 251–62 (1932).—Investigations have shown that these clays may be used for sagger manufacture. The addition of 10% kaolin improves the quality of saggers. The argillaceous "balykes" are better than the sandy ones. As coarsening materials, the wastes of kaolin manufacture and fired sand may be used. The best results have been obtained with grog of the following granulometric composition: 4 to 2 mm. 50%, 2 to 0.5 mm. 10%, and 0.5 to 0.05 mm. 40%. S.I.P.

Manufacture of porcelain artificial teeth in Ukraine. A. SIDORENKO. *Ukrainsky Silikaty*, No. 10, pp. 276–80 (1932).—The properties of the batch components of the porcelain mass including coloring agents are given. The methods of manufacture are briefly described. The tests of the teeth have shown that their quality is equal to the best of foreign manufacture. S.I.P.

Manufacture of spark-plug insulators from steatite of the Urals. O. V. TERESHTCHENKO, E. V. IVANOV, D. S. CHOKOLOV, AND M. A. NABOKOVA. *Ukrainsky Silikaty*, No. 10, pp. 267–76 (1932).—Investigations have shown that washed steatite may be successfully used for

this purpose. The best composition is washed steatite 79% (by weight), refractory clay of Chassov-Yar (a high plastic clay) 10%, fine-ground feldspar 10%, and high-grade dextrin 1%. The moisture of the mass is 6.5 to 7%; pressure, 299 kg./cm.^{2}. The mix is fired to 1320°C after glazing. The properties of foreign products (Champion, Bosch, Titan, etc.) were studied and compared with the experimental ones. S.I.P.

Manufacture and test of high-voltage insulators in the United States. M. L. SHAPIRO. *Ukrainsky Silikaty*, No. 4–5, pp. 107–18; No. 6–7, pp. 161–85 (1932).—S. discusses the manufacture and testing of high-voltage insulators in detail from economical and engineering viewpoints. Illustrated. S.I.P.

Pyrophyllite as a ceramic material. L. V. OMININ. *Ukrainsky Silikaty*, No. 6–7, pp. 136–40 (1932).—The research work was carried out at the State Ceramic Institute at Leningrad (G.I.C.I.). The chemical and mineralogical composition and the ceramic properties of pyrophyllite were studied. The refractoriness of the specimens fluctuates between 1670 and 1725°C. This mineral may be used instead of kaolin for whiteware manufacture, as in the composition ($Al_2O_3 \cdot 4SiO_2$) it is analogous to kaolinite ($Al_2O_3 \cdot 2SiO_2$) and has a great refractoriness and a comparatively small shrinkage during firing. See also *Ceram. Abs.*, **12** [8], 303 (1933). S.I.P.

Use of low-grade raw materials for high-voltage insulator manufacture. E. I. ORLOV, A. G. GRYSHKO, AND A. A. PIROGOV. *Ukrainsky Silikaty*, No. 8, pp. 206–209 (1932). S.I.P.

BOOK REVIEWS

Defects of Household Porcelain and Methods of Their Elimination. A. I. YOSSEWITCH. Ukrainian State Pub. House of Light Industry, Kharkov, U.S.S.R., 1933. 72 pp. Price 1 R, 35 kopecks. This is a small, popularly written brochure dealing with the defects encountered in the separate stages of porcelain manufacture: molding, firing, glazing, and decoration. The process of sagger manufacture, their mending, and use are briefly discussed. A few pages are devoted to the manufacture of gypsum molds.

S. I. PERKAL

Manufacture of Earthenware. I. A. DOROSHEV. 2nd ed., revised and enlarged. State Chem. Tech. Pub. House, Leningrad, 1933. 136 pp. 83 figs. Price 2 R, 30 kopecks. This popularly written book deals with raw materials and their preparation, molding, drying, firing, and decoration of earthenware. A chapter is devoted to manufacture and mending of saggers. A list of Russian reference literature on ceramics is given. This illustrated and well-printed book will be useful for a first acquaintance with earthenware manufacture. S. I. PERKAL

PATENTS

Detergent composition. M. C. TAYLOR (Mathieson Alkali Works, Inc.). U. S. 1,894,207, Jan. 10, 1933. A detergent salt mixture forms in water a solution containing a water-soluble detergent and a bacteriacide, the detergent being at least equal in amount to the amount of the bacteriacide and the mixture comprising a water-soluble detergent alkali metal salt of an acid forming an insoluble calcium salt and a minor proportion, with respect to the alkali metal salt, of a stable calcium hypochloride.

Electrical insulator. J. A. WILLOUGHBY. U. S. 1,957,481, May 8, 1934.

High tension insulator. K. A. HAWLEY (Locke Insulator Corp.). U. S. 1,958,435, May 15, 1934.

High voltage terminal construction. F. S. SMITH. U. S. 1,957,982 and 1,957,984 to 1,957,986, May 8, 1934.

High voltage terminal construction and method of assembly. F. S. SMITH. U. S. 1,957,983, May 8, 1934.

Safety flushing apparatus. M. J. TRACY (Pauly Jail Building Co.). U. S. 1,956,085, to 1,956,087, April 24, 1934.

Suspension insulator. E. E. ARNOLD (Westinghouse Electric & Mfg. Co.). U. S. 1,958,880, May 15, 1934.

Toilet bowl. F. A. SCHOSSOW. U. S. 1,957,809, May 8, 1934. HARRY HAGUE AND T. H. CROWTHER. U. S. 1,957,831, May 8, 1934.

Ceramic wash basin. F. H. ROGERS (Keramag Keramische Werke A.-G.). Brit. 408,516, April 18, 1934.

Water closets, commodes, etc. F. G. REES. Brit. 408,607, April 25, 1934.

Equipment and Apparatus

Balance-plastometer; a simple instrument for measuring plasticity and recovery of soft materials. J. HOEKSTRA. *Physics*, **4** [8], 285–88 (1933).—The principle of this instrument is as follows: a bar is fixed to the long arm of a balance with unequal arms; the vertical displacement of this bar, which rests on a specimen of the material to be investigated, is magnified fifty times and read on a scale. The specimen rests on a second bar with a known cross-section. The first-named bar can be loaded with a known weight, and this weight can be removed at will. The instrument offers advantages when used to measure the plasticity as well as when used to study the recovery.

Ball-bearing motors cut pottery costs. FRANCIS A. WESTBROOK. *Elec. World*, **103** [8], 302 (1934).—The experience of the Mt. Clemens Pottery Co. in its use of ball-bearing motors in plant modernization with consequent reduction of costs and improvement of efficiency is given. A.K.

Ball granulators. ALLIS-CHALMERS MFG. CO. *Ind. Eng. Chem., News Ed.*, **12** [8], 164 (1934).—Many illustrations and tables show the various sizes and details of construction. F.G.H.

Determination of the optic angle with the universal stage. THEODORE A. DODGE. *Amer. Mineral.*, **19** [2], 62–75 (1934).—With the universal stage, direct measurement of the optic angle of a biaxial crystal by rotation from a bisectrix to one or both optic axes is frequently not possible. Berek's graphical method of determination for this case is outlined and modified to give greater flexibility and usefulness by the addition of a more comprehensive group of curves. These permit the attainment of the maximum accuracy possible under any given set of conditions

The method involves only a few simple rotations on the universal stage and is equally applicable to the old or new models. Used with the modified instrument having two east-west axes, the new curves form an integral part of universal-stage procedure involving no graphical construction on the part of the operator and no corrections during experimental procedure. In the determination of optic angle with the Fedorov stage they afford a most valuable check whenever the complete angle, $2V$, can not be measured directly. A.K.

How to get better seeing. SAMUEL G. HIBBEN. *Factory Management & Maintenance*, **92** [3], 99–102 (1934).—H. considers the problems of industrial lighting. A series of sketches of lighting fixtures shows the type best adapted for particular situations and requirements. A table of lamp efficiencies shows that this increases with the size of the lamp. A table of undesirable lighting conditions lists possible causes for each defect. A list of 14 warnings for lamp users is included. Illustrated. J.L.G.

How to survey your plant for better seeing. G. A. VAN BRUNT. *Factory Management & Maintenance*, **92** [3], 106–108 (1934).—A photoelectric photometer for measuring light intensities and a suitable chart for recording the results are described and illustrated. Suggestions for improving light conditions are included. Illustrated. J.L.G.

Improving the quality of tile through mechanical treatment. G. STRECK. *Tonind.-Ztg.*, **58** [21], 266–69; [22], 278–81 (1934).—Different types of machines employed for improving the quality of the raw mix are described. Illustrated. M.V.K.

Interferometer microscope. C. DUNBAR. *Jour. Sci. Instruments*, **11** [3], 85–89 (1934).—D. describes a mechanical stage for a microscope which can be moved smoothly through small distances. Displacements of the stage are measured by the interferometer system, so that magnification of the microscope can be measured without using a subsidiary test object. The concentration of small particles can be measured. A second interferometer measures the distance through which the microscope is focused and defines a volume in which particles can be counted. Illustrated. J.L.G.

Laying out group drives. ROBERT W. DRAKE. *Factory Management & Maintenance*, **92** [3], 131–33 (1934).—Size of drives, group drive losses, use of cross-belts, and making up the drives are considered. J.L.G.

Motor protection for severe conditions. PAUL W. ARNOLD. *Factory Management & Maintenance*, **92** [3], 128–30 (1934).—Types of inclosures for both alternating- and direct-current motors are illustrated. J.L.G.

New high frequency calorimeter for determining dielectric losses of liquids. L. PUNGS AND H. RIECHE. *Z. tech. Physik*, **14** [11], 483–85 (1933).—This calorimeter will avoid the disadvantages of the older types, such as long time interval for the experiments and great losses. The new calorimeter may be used in the frequency range from 0 to 5×10^7. W.M.C.

New low-priced test kiln. ANON. *Glass Ind.*, **15** [4], 66–67 (1934); *Ceram. Ind.*, **22** [5], 278 (1934).—The Electrikiln is portable, has a muffle space of $3\frac{1}{2}$ x $3\frac{1}{2}$ x 4 in., operates from any light socket, and is capable of attaining temperatures of 1950 to 2000°F. Construction details are given. Illustrated. E.J.V.

New type rotary spray machines for small articles. DEVILBISS CO. *Ceram. Age*, **22** [5], 149 (1933).—Illustrated. F.G.H.

Portable brightness meter. B. H. CRAWFORD. *Jour. Sci. Instruments*, **11** [1], 14–17 (1934).—A portable brightness meter or illuminometer is described. Illustrated. J.L.G.

Relations between friction, heat-transmission, and evaporation. W. FINDEISEN. *Gerlands Beitr. z. Geophys.*, **39**, 356 (1933).—The relations between air-friction, heat transition, and evaporation at the surface of substances are discussed on the basis of the limiting layer theory. Definite equations are evolved for the cases of a turbulent and a nonturbulent limiting layer, and numerical values of the exchange coefficients are deduced in both cases. (*T.C.S.E.*)

Removal of "nonmagnetic" impurities from ceramic materials. G. W. JARMAN, JR. *Bull. Amer. Ceram. Soc.*, **13** [5], 126–29 (1934).

Researches on drying solid materials. III–IV. Drying of clay. SABURO KAMEI AND TAMOTSU SEDOHARA. *Jour. Soc. Chem. Ind.* [Japan], **37** [2], 68–77*B* (1934).—The following problems were studied: (1) effect of temperature, humidity, and velocity of drying air on rate of drying; (2) relationship between rate of drying and mixing proportions of quartz and feldspar with kaolin; (3) relationship between rate of drying and kinds of liquids contained in kaolin; (4) relationship between rate of drying and grain size of quartz present in kaolin; (5) relationship between rate of drying, thickness of samples, their shape, and direction of drying air; (6) effect of electrolyte on rate of drying; (7) effect of preheating clay on rate of drying; (8) relationship between rate of drying and cracking of clay. Diagrams show the results. For Part II see *Ceram. Abs.*, **13** [4], 95 (1934). M.V.K.

Seger's volumenometer. V. KRAFT AND V. LEBEDEV. *Ukrainsky Silikaty*, No. 6–7, pp. 146–48 (1932).—Some changes in the construction of this apparatus which make it easier to use are described. S.I.P.

Terminology of ceramic whiteware. ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **13** [5], 131 (1934).

Thermodynamic properties of moist air. JOHN A. GOFF. *Heating, Piping & Air Conditioning*, **6** [3], 117–23 (1934).—A 2-page table of the properties of various mixtures of air and water vapor is included. J.L.G.

Vacuum press for wire cutting. A. C. HEIDL. *Tonind.-Ztg.*, **58** [24], 311–12 (1934).—A discussion of some American and German vacuum presses is presented. Illustrated. M.V.K.

Wear of dies for extruding plastic clay. R. T. STULL. *Bur. Stand. Jour. Research*, **12** [4], 501–17 (1934).—A study was made of dies of 20 metals and alloys and dies of porcelain to determine their relative resistance to wear by a plastic clay and sand mixture, termed No. 1. The approximate angle of constant wear rate was determined for the specific dies used. In addition, tests were made on one die material to determine the relative abrasive intensities of a plastic porcelain body (clay No. 2) and clay No. 1. A constant volume of the abrasive material in the stiff-mud condition was extruded from the dies at a constant volume

rate and their wear losses were determined. Vicker's hardness numbers of the specimens were also determined. Analysis of the data warrants presentation of the following results and conclusions: (1) The relative service values ranged from 3.22 for a brass to 1673 for a cobalt-chromium-tungsten alloy. (2) Tests of different dies of a chromium tool steel which had received 5 different heat treatments yielded service values from 38.26 for annealed dies to 147.8 for dies heated to 1650°F and hardened in air blast. (3) Under constant working conditions, dies with cylindrical orifices wear toward a tapered orifice, a wear rate constant within the limits of the tests obtained. The relation between wear rate and time for a die in wearing from a cylindrical orifice to a taper of "constant wear rate" is of the character $(a + u)(b - v) = R$, in which v is wear rate, u, time equivalent, and a, b, and R are constants. (4) The relation between wear loss and extrusion pressure is of the character $y = \frac{P^m}{K}$ in which y is "wear coefficient," P, extrusion pressure, m, constant for all materials, and K, "wear resistance coefficient," a specific constant for a die material of uniform wear resistance and representing its ability to withstand abrasion, that is, its "relative service value." (5) No correlation between Vicker's numbers and service values was obtained for dies of unlike materials, but there is in general a direct relation for dies made of materials of the same character. (6) The wear resistance of nitrided steel dies decreased, increased, and then decreased as layers of different depths of the case were removed. (7) Within the experimental limits the wear resistance of porcelain dies decreases with depth asymptotically according to the equation $(K - a)(d + b) = G$, in which K is wear-resistance coefficient, d, depth, and a, b, and G are constants. (8) Comparison of the relative abrasive intensities of a plastic porcelain body and a plastic clay-sand mixture on dies of one material was found to be $\frac{z}{y} = \frac{1.99}{p^{0.708}}$ in which z is wear-resistant coefficient when using the plastic porcelain body (clay No. 2) as the abrasive, y, the wear coefficient when using the plastic clay-sand mixture (clay No. 1) as the abrasive, and p, the extrusion pressure. R.A.H.

Wear of raw materials in mill linings. Communication of the STEATITE MAGNESIA CO. *Sprechsaal*, **67** [9], 119–21 (1934).—The durability of materials used for lining mills is usually evaluated on the basis of grinding and sand-blasting tests. The latter test is the best. It was found that pressed lining brick from steatite are far superior to linings made of other ceramic materials or natural flint. Plant experience has proved that steatite linings have an exceptional life. M.V.K.

Workers are human seeing-machines. MATTHEW LUCKIESH. *Factory Management & Maintenance*, **92** [3], 93–96 (1934).—The difference between barely seeing and seeing with ease is the difference between unnecessarily wasting and conserving the nervous energy that is the most valuable possession of every worker. For best efficiency, lighting must be considered from three standpoints: (1) quantity of light or intensity of illumination, (2) quality of light, usually its approach to daylight, and (3) quality of lighting, which involves the direction, distribution, and diffusion of light. Illustrated. J.L.G.

BOOK REVIEW

Electrical Pyrometers. G. P. KULBUSH. State Energetical Pub. House, Moscow and Leningrad, 1932. 408 pp., 331 figs. Price 5 R, 50 kopecks. This manual has five divisions embracing 11 chapters as follows: I. Thermoelectrical pyrometers: (1) technical thermocouples (their theory, graduation, and normalization; auxiliary devices used to switch on thermocouples); (2) electromeasuring apparatus (galvanometers, compensation apparatus used for measuring thermal e.m.f. of thermocouples). II. Resistance thermometers: (1) electrical thermometers, (2) measuring instruments for resistance thermometers (Wheatstone's bridge, ohmmeters, a.-c. thermometers, network, and switches; special cases of the use of resistance pyrometers). III. The conditions of thermal equilibrium between the pyrometer and the medium of the measuring temperature: (1) the basic laws of heat transmission; the temperature measurement of gases and liquids, (2) temperature measurement of solid bodies and surfaces and thermal inertia of pyrometers. IV. Optical and radiation pyrometers. V. Recording and automatic pyrometers; pyrometric installations: (1) recording galvanometers, and (2) signalizers and thermoregulators. The book is a good, systematic outline of theoretical and industrial foundations of pyrometry and pyrometric apparatus. It may be favorably compared with the best books on this subject in the world literature. S. I. PERKAL

BULLETIN AND BOOKS

Combustion meters. HAYS CORP. *Ind. Eng. Chem., News Ed.*, **12** [7], 136 (1934).—Illustrated. F.G.H.

Design and Use of Instruments and Accurate Mechanism. Underlying Principles. T. N. WHITEHEAD. Macmillan Company, New York, 1934. 283 pp. Price $3.50. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [5], 1256 (1934). F.G.H.

Determination of Drying Time (Die Berechnung der Trockendauer). W. Fabricius. V.D.I. Verlag, Berlin. 42 pp. 2.50 Rm. (Paper.) Reviewed in *Mining & Met.*, **15** [329], 4 (1934).—The investigation was made on the factors which control the time required to dry materials. A formula was developed which will enable the designer of drying plants to determine the influence of each factor upon the drying process and so to design the most economical plant for any purpose. E.J.V.

Industrial Filtration (La Filtration Industrielle). G. GENIN. Dunod, Paris, 1934. 446 pp. Price 98 F. Reviewed in *Ind. Eng. Chem., News Ed.*, **12** [8], 157 (1934).—Rotary filters and plate filter presses are described in detail in this volume. F.G.H.

Industrial Radiography. A. ST. JOHN AND H. R. ISENBURGER. John Wiley & Sons, New York. 232 pp. Price $3.50. Reviewed in *Mining & Met.*, **15** [329], 4–5 (1934).—The general principles that govern the production and use of X-rays and γ-rays are set forth clearly, together with the special technique suitable for important classes of materials. E.J.V.

PATENTS

Ceramic process. T. G. MCDOUGAL (A C Spark Plug Co.). U. S. 1,955,821, April 24, 1934. The method of producing aluminum silicates of substantial amorphous

content for use in the manufacture of ceramic shapes consists in heating the material to fusion, dividing the material into small particles, and subjecting the particles to rapid cooling action.

Means and method of excavating and transporting earthy materials. R. S. WEIMER. U. S. 1,956,738, May 1, 1934.

Slotting clay column. J. B. WHITACRE (Whitacre-Greer Fireproofing Co.). U. S. 1,957,056, May 1, 1934.

Clay-working machines. W. C. FAIRWEATHER (International Clay Machinery Co.). Brit. 408,740, April 25, 1934.

Manufacture of ceramic earthenware, etc. RAINFORD POTTERIES, LTD., AND F. W. GRUNDY. Brit. 409,258, May 2, 1934.

Kilns, Furnaces, Fuels, and Combustion

Application of heavy oil for firing ceramic furnaces. P. BIGOT. *Rev. mat. constr. trav. pub.*, No. 292, pp. 1–7*B*; No. 293, pp. 21–26*B* (1934).—A detailed discussion is given of the properties and advantages in using heavy oil in different types of ceramic kilns. Illustrated. M.V.K.

Banded constituents of coal. Interrelationships deduced from analytical data. A. M. WANDLESS AND J. C. MACRAE. *Fuel Sci. Practice*, **13** [1], 4–15 (1934). F.G.H.

Colloidal solution of coal. J. M. PERTIERRA. *Fuel Sci. Practice*, **13** [1], 23–26 (1934). F.G.H.

Commercial sampling and analysis of coke. R. A. MOTT AND R. V. WHEELER. *Trans. Inst. Mining Eng.*, **86** [12], 111 (1933); abstracted in *Fuel Sci. Practice*, **13** [1], 32 (1934); see also *Ceram. Abs.*, **12** [5], 201 (1933). F.G.H.

Distribution of radiant heat. W. J. G. DAVEY AND H. BARNES. *Gas World*, **99**, 621 (1933); abstracted in *Fuel Sci. Practice*, **13** [1], 31 (1934). F.G.H.

Errors in gas analysis and their influence. H. W. NEIDHARDT. *Arch. Wärmewirt.*, **14** [4], 85 (1933); abstracted in *Fuel Sci. Practice*, **12** [7], 253 (1933). F.G.H.

Future of the hydrogenation of coal. G. N. CRITCHLEY. *Fuel Sci. Practice*, **13** [1], 27–28 (1934). F.G.H.

Length of firing channel in annular kilns. P. THOR. *Tonind.-Ztg.*, **58** [17], 208–209 (1934).—The firing performance of annular kilns is discussed. Tables are given. It is shown that for increasing the firing performance of an annular or zigzag kiln, the lengthening of the firing channel is unnecessary and even detrimental in some cases. M.V.K.

Modern developments in drying and firing. L. T. DAVIES. *Claycraft*, **7**, 66 (1933).—The possibilities of reducing production costs are discussed with special reference to drying and firing in the light of recent experience with Bührer design. Bührer driers are classified into tunnel driers, rack driers over kilns, chamber and corridor driers. The Bührer zigzag kiln, a modification of the Hoffmann, is described in detail. (*T.C.S.E.*)

Operation of rotary grate gas producers with filling hopper and mantle cooling. H. DENEKE. *Gas- & Wasserfach*, **77** [9], 129–31, 149–54, 168–73 (1934).—Coking and gasification phenomena are studied with particular reference to gasification of coarse coke in the rotary grate gas generator. The disintegration of the steam used in the process takes place according to $C + 2H_2O \longrightarrow CO_2 + 2H_2$. The thermal efficiency in a great many experiments under operating conditions was between 83 and 89%; the amount of disintegrated steam varied from 69 to 97%. Curves and tables for different kinds of fuel supplement the practical data. A reference list is given. M.H.

Silit II heating elements. FR. J. MANN. *Siemens-Z.*, **13** [4], 155–58 (1933).—Silit is a nonmetallic ceramic material of hard silicon carbide crystals pressed into rods or other forms (D.R.P. 176,001 and 177,252); it can be used up to 1400°C. The specific gravity is 2.96, tensile strength 700 kg./cm.^{2}, specific heat 0.17, and the linear expansion coefficient between 20 and 1400° about 5.6×10^{-6} mm. per °C. Specific electric resistance is between 1000 and 2000 ohms per mm.^{2} and m. length; temperature coefficient is negative up to 900°; above, it is weakly positive or negative according to initial resistance. Some typical applications are described. M.H.

Technique and theory of control of temperature gradient. MAX LANG. *Elektrowärme*, **4** [4], 83–86 (1934).—The problem and methods of temperature regulation of large industrial furnaces is discussed and formulas for proper regulation are developed. M.H.

BULLETIN AND BOOK

Action of solvents on coal. W. E. BAKES. *Fuel Research Tech. Paper*, No. 37. H. M. Stationery Office, London. Price 4s, 6d. *Fuel Sci. Practice*, **13** [1], 32 (1934). F.G.H.

Manufacture of Gas. Vol. I. Water Gas. Edited by H. HOLLINGS. Vol. I by R. H. GRIFFITH, with a section on Temperature Measurement by H. C. EXELL. Ernest Benn, Ltd., London, 1934. 260 pp. Price 36s. Reviewed in *Ind. Eng. Chem., News Ed.*, **12** [7], 131 (1934). F.G.H.

PATENTS

Construction for use in firing brick. A. H. MALLERY. U. S. 1,956,803, May 1, 1934. A construction comprises in combination a series of scoving sections.

Kiln. H. M. ROBERTSON. U. S. 1,958,448, May 15, 1934. A kiln consists of contiguous preheating, firing, and cooling zones disposed concentrically to trackage.

Regenerators for furnaces. BONNYBRIDGE SILICA & FIRECLAY CO., LTD., AND W. MCBRYDE. Brit. 408,752, April 25, 1934.

Geology

Additional notes on laumontite and thomsonite from Table Mountain, Colorado. E. P. HENDERSON AND JEWELL J. GLASS. *Amer. Mineral.*, **18** [9], 402–406 (1933).—Table Mountain, a geological feature near Golden, Colo., has long been known as a locality for zeolites. This paper places on record two new analyses and accompanying optical data. No additional relationships between the different zeolites at this locality were noted. A.K.

Bauxite industry in 1933. ANON. *Mining Congress Jour.*, **20** [4], 41 (1934).—Shipments of bauxite from mines in the U. S. in 1933 were 154,176 long T., valued at $923,-259, an increase of 60% in quantity and of 68% in total value compared with 1932. The producers of domestic bauxite reported sales during 1933 at prices ranging from $4 to $11.50 a long T. A.K.

Diffusion of water in a zeolite crystal. ARNE TISELIUS. *Nature*, **133** [3354], 213 (1934).—The diffusion of water through a crystal of heulandite was studied by means of the movement of the dark bands which such a rehydrating crystal exhibits when placed between crossed nicols. Exact measurements were made using a vacuum container. Photographs of the lines obtained in the experiments are given. Measurements show that the displacement of each band is proportional to the square root of time in agreement with Boltzman's general diffusion equation. J.L.G.

Formation of α-Fe_2O_3 from γ-$Fe_2O_3 \cdot H_2O$ by rubbing. OSKAR BANDIRCH AND LARS A. WELO. *Naturwissenschaften*, **21** [32], 593 (1933).—On grinding γ-$Fe_2O_3 \cdot H_2O$ in a ball mill, it is changed into α-Fe_2O_3. X-rays were employed in determining the change. L.T.B.

Magnesite in Canada. M. E. WILSON. *Can. Mining Jour.*, **55** [5], 239–41 (1934).—The only extensively mined magnesite is in Argenteuil County, Quebec. The deposits are formed by replacement of limestone through the agency of magnesia-bearing solutions. Deposits formed by the alteration of serpentine derived from ultrabasic igneous rocks occur in the eastern townships of Quebec, in British Columbia, and in the Yukon. Superficial deposits of hydromagnesite occur in several localities in British Columbia. At Cranbrook, B.C., sedimentary magnesite is formed under arid climatic conditions. G.M.H.

Microscopic relations of magnetite, hematite, pyrite, and chalcopyrite. F. N. GUILD. *Econ. Geol.*, **29** [2], 107–20 (1934).—Illustrated by photomicrographs. J.L.G.

National clay mining industry. GEORGE C. CROSSLEY. *Mining Congress Jour.*, **20** [2], 12 (1934).—A comprehensive survey of the importance and scope of the clay mining industry is given. A.K.

Notes on the volatile transport of silica. J. W. GREIG, H. E. MERWIN, AND E. S. SHEPHERD. *Amer. Jour. Sci.*, **25**, 61–73 (1933).—At high temperatures the presence of a small pressure of the volatile matter from rocks brings about a transfer of silica through the vapor phase at an important rate. Water is particularly effective. Without these "volatiles" the rate is inappreciable. Since the vapor assisting the transfer is not used up but continues its action a large amount of silica may be moved. Crystals of cristobalite so formed are described and photomicrographs are given. Crystallization can be induced in liquid silicates by this method. Contamination of melts by silica can also occur in this manner. J.B.A.

Physicochemical investigation of clays of Pyatikhatka and Zinovyevsk deposits. O. V. TERESHTCHENKO AND E. V. IVANOV. *Ukrainsky Silikaty*, No. 9, pp. 233–41 (1932). S.I.P.

Progressive metasomatism in the flint nodules of the Scawt Hill contact zone. C. E. TILLEY AND A. R. ALDERMAN. *Mineralog. Mag.*, **23** [144], 513–18 (1934).—An interesting group of mineral assemblages which have developed by a progressive metasomatism of these siliceous bodies is given. Three types of altered nodules may be distinguished. A.K.

Silica glass from the Libyan desert. P. A. CLAYTON AND L. J. SPENCER. *Mineralog. Mag.*, **23** [144], 501–508 (1934).—An occurrence of silica glass in lumps up to 10 lb., smaller fragments being scattered over an area at least 80 by 25 km., has been discovered in the work of the Eyptian Desert Surveys. This material appears to be closely related to tektites but is found in much larger masses and in larger quantity than any tektites previously known. The origin of the silica glass remains an unsolved problem. More observations are needed. A.K.

Sodalite from Bolivia. WOLFGANG BRENDLER. *Amer. Mineral.*, **19** [1], 28–31 (1934).—This sodalite occurs in a large dike on the east side of the Cerro Sapo at an elevation of 13,000 ft. The Cerro Sapo sodalite is always coarsely crystalline and shows good dodecahedral cleavage. The color of the fresh material is a fine dark ultramarine blue. The specific gravity of the selected pure material is found to be 2.295 ± 0.001 at 14.5°C. The average refractive indices are as follows: N_{Li} −1.4806; N_{Na} −1.4837; N_T −1.4868. The three chemical analyses given are in good accord with the formula, $3NaAlSiO_4 \cdot NaCl$. A.K.

Story of Canadian mining. II. FREDERICK EDWARDS. *Can. Mining Jour.*, **55** [5], 243–47 (1934).—The beginning of the career of Sir William Logan, founder of the Canadian Geological Survey, is given. For Part I see *Ceram. Abs.*, **13** [6], 160 (1934). G.M.H.

Studies on the zeolites. VI. Edingtonite. MAX H. HEY AND F. A. BANNISTER. *Mineralog. Mag.*, **23** [144], 483–94 (1934).—Edingtonites from Old Kilpatrick and from Böhlet have been shown to be essentially identical. For Parts IV and V see *Ceram. Abs.*, **13** [4], 99 (1934). A.K.

Zoisite and other minerals included in mica from Spruce Pine, North Carolina. GEORGE M. HALL. *Amer. Mineral.*, **19** [2], 76–80 (1934).—Details are given of an investigation of zoisite, hematite, garnet, quartz, and other minerals found in mica from the Chestnut Flat mine. The mine is operated for feldspar which is chiefly microcline. A.K.

BOOK REVIEWS

Diabase and Basalt. N. KARANDASHEV. District Pub. House, Leningrad, 1932. 24 pp. Price 50 kopecks. This brochure emphasizes the value of melted diabase and basalt for the electrical, chemical, building, and metallurgical industries. The chemical, physical, and mechanical

properties of natural and melted diabase and basalt are given. The process of diabase and basalt melting and their casting and annealing are discussed.

S.I.PERKAL

Electrical Prospecting of Ore Bodies Based upon Measurement of Alternating Magnetic Fields. V. K. FREDERICKS. Published by the Geol. Comm., Leningrad, 1929. 137 pp. Price 1 R, 75 kopecks. In the first part of this book F. describes some properties of an alternating magnetic field produced by an electric alternating current and methods of its measurement. The second part is devoted to the so-called "normal magnetic field," and the last part deals with the results of application of electrical prospecting to some ore lots.

S.I.PERKAL

Nepheline and Its Uses. D. I. SHCHERBAKOV. Pub. House of the Academy of Sci., Leningrad, 1932. 12 pp. Price 15 kopecks. Nepheline (eleolite) consists of 44% silica, 34% alumina, and 21 to 22% alkalis. Its formula is $(Na, K)_2O \cdot Al_2O_3 \cdot 2SiO_2$. S. emphasizes that because of this composition the following possible separate components or their combinations may be used: (1) alkalis, (2) alumina, (3) silica, (4) alkalis and alumina without silica, (5) alkalis and silica without alumina, (6) alumina and silica without alkalis, and (7) all three components, alkalis, alumina, and silica, *i.e.*, nepheline by itself. The process of decomposition of nepheline will depend in the first place on the arrangement of separate particles in the crystalline lattice of this mineral. This fact is of great interest showing how closely theory and practice are related and how deeply the theoretical questions should be examined in order to solve problems of industrial character correctly. This example sharply emphasizes the rôle which the study of the constitution of the crystalline lattice of a substance and the arrangement of atoms in it will play. The behavior of atoms and ions in the lattice of a crystal determines its behavior in geochemical and technological processes. This statement should be regarded as the greatest achievement of theoretical character in solving the nepheline problem on the whole. In general, by adopting the corresponding methods of splitting up of nepheline and the necessary technological processes, this mineral may be used in the glass, ceramic, chemical (soda ash, silica gel, sulfate), leather, rubber, permutite, and other industries.

S. I. PERKAL

BOOKS

Earth-Lore: Geology without Jargon. S. J. SHAND. viii + 134 pp., 4 plates. Thomas Murby and Co., London, 1933. Price 5s net. Reviewed in *Nature*, **133** [3350], 48 (1934).—Simple explanations have been given for such technical terms as are used. Subjects considered include earth sculpture, the sea floor, the age of the earth, the problem of the mountains, and drifting continents.

J.L.G.

Mineral Industry during 1932. Vol. 41. G. A. ROUSH (editor). McGraw-Hill Book Co., New York, 1933. 680 pp. $12.00. Reviewed in *Jour. West. Soc. Eng.*, **39** [1], 15 (1934). An extensive review of the statistics, technology, and trade of the major metals and minerals during 1932 is given.

J.L.G.

Chemistry and Physics

Apparatus for measuring the thermal conductivity of metals up to 600°C. M. S. VAN DUSEN AND S. M. SHELTON. *Bur. Stand. Jour. Research*, **12** [4], 429–40 (1934).

R.A.H.

Collected references to the microchemistry of aluminium, chromium, iron, titanium, and uranium. K. HELLER. *Mikrochemie*, **12**, 327–54 (1933); *Analyst*, **58**, 305 (1933).—References are given to 146 original papers.

H.H.S.

Collected references to the microchemistry of cobalt, nickel, manganese, and zinc. K. HELLER. *Mikrochemie*, **12**, 375–95 (1933); *Analyst*, **58**, 305 (1933).—References are given to 101 original papers.

H.H.S.

Colorimetric determination of small amounts of magnesium. J. TISCHER. *Mikrochemie*, **12**, 65–86 (1932); abstracted in *Analyst*, **58**, 247 (1933).

H.H.S.

Colorimetric method of quantitative determination of titanium in silicates. N. I. BOODAKOV. *Ukrainsky Silikaty*, No. 10, pp. 285–87 (1932).—After a review of the defects of the usual method of titanium determination with the colorimeter, B.'s simplified method is outlined as follows: A 0.5-g. sample of the test material, *e.g.*, clay, kaolin, grog brick, quartzite, etc., containing a small quantity of TiO_2 is fused in a platinum crucible with a quantity of Na_2CO_3 or $NaHCO_3$ 6 to 7 times that of the test material. The melt in the platinum crucible is plunged in a flask filled with 25 cc. of water. Then 6 cc. strong sulfuric acid are added to neutralize the soda and to obtain a solution containing 5% of free sulfuric acid. If the SiO_2 is separated out in the precipitate, about 100 cc. of water should be added and the mix should be filtrated quickly through a filter into a 200-cc. flask. The precipitate on the filter is washed with 60 cc. of 5% sulfuric acid; 3 to 5 cc. of 3% solution of hydrogen peroxide is added; it is cooled to room temperature and diluted exactly to 200 cc. and the TiO_2 is determined colorimetrically as usual. In order to verify this method, a special mixture of calcined pure Kahlbaum's preparation is prepared (TiO_2 is obtained by precipitation with aqueous NH_3 from a solution of $Ti(SO_4)_2$). For this determination, a mixture of the following composition was tested: SiO_2 60%, 900 mg.; Al_2O_3 28.5%, 427 mg.; Fe_2O_3 10%, 150 mg.; and TiO_2 1.50%, 22.5 mg. The direct determination of TiO_2 by this method gives the following results: TiO_2 introduced, 1.50; TiO_2 estimated, 1.52 and 1.44. The suggested method has many advantages: exactness, rapidity, cheapness, etc., and is recommended for use.

S.I.P.

Colorimetry of titanium. III. Note on the general methods of colorimetry. H. GINSBERG. *Z. anorg. allgem. Chem.*, **211** [4], 401–11 (1933).—With the aid of absolute color measurement by the use of the Leitz three-stage universal colorimeter, proof was given that in titanium colorimetry the Lambert-Beer law is obeyed in the concentration range 4 to 0.2 mg./100 cc. A series of

measurements is reported. The method is applicable for small amounts of TiO_2 in the presence of chromium, vanadium, molybdenum, etc. For Part I see *Ceram. Abs.*, **10** [9], 664 (1931); for Part II, *ibid.*, **12** [2], 82 (1933). L.T.B.

Complementary notes on a rapid method of analysis of soda-lime glasses and its application for potash glasses. M. A. NOEL. *Verre & Silicates Ind.*, **5** [5], 86–87 (1934).—During the analysis of soda-lime glasses (*Rev. belge ind. verrières*, March and April, 1932) it was found that alkalis sometimes contained calcium salts. The presence of these salts is due to the solubility of a part of the precipitated calcium carbonate obtained during the transformation of sulfate in the presence of sodium carbonate. This fact led to a slight change in the procedure of analysis. The residue of the sulfohydrofluoric attack is treated with hot water and decanted. The solution is diluted with 300 to 350 cc. water; 1 cc. perhydrol and 25 cc. *n*/2 sodium carbonate solution are added. It is heated to boiling, 0.25 g. ammonium oxalate is added, and the whole is boiled. After cooling, it is filtered in a double filter and washed with cold water containing 0.25 g. ammonium oxalate until the reaction is ended. The determination of alkalis proceeds as before. The alkalis, after weighing, are treated with water, and the solution is precipitated by boiling with surplus ammonia using methyl orange as indicator. This operation is necessary to obtain the alumina carried away by alkalis in the form of sodium aluminate. This alumina is subtracted from the weight of alkaline sulfates and added to the total oxides found. This method produced excellent results with soda-lime glass and was used for soda-lime-potash glasses. The determination of potash is controlled by two methods: (1) determining potash by means of platinum chloride in the sulfate weighed; (2) determining the SO_3 corresponding to alkaline sulfates weighed. This method can be applied not only for soda-lime glasses but also for lime glasses containing potash alone or with soda. See also *Ceram. Abs.*, **12** [3], 100 (1933); **13** [4], 102 (1934). M.V.K.

Detection of heavy metals by diphenylthiocarbazone. H. FISCHER. *Chem.-Ztg.*, **57**, 523–24 (1933); abstracted in *Analyst*, **58**, 567 (1933). H.H.S.

Electrolysis of molten silicates and preparation of silicon and silicides. L. ANDRIEUX AND M. DODERO. *Compt. rend.*, **198** [8], 733–55 (1934).—The disintegration of silicates in molten state by electrolysis was investigated; electrolytic preparation of Si and silicides by secondary cathodic reaction was found possible. M.H.

Employing precipitated barium carbonate in ceramics. ANON. *Verre & Silicates Ind.*, **5** [5], 94 (1934).—The advantages in using barium carbonate are (1) when employed in small amounts (depending on the quality of clay used), it promotes the elimination of sulfate in clay; (2) it suppresses efflorescence and swelling, diminishes porosity, and insures a good polishing of the ware; (3) by simply applying it on the surface after firing, a resistant and brilliant glaze is obtained; (4) it prevents the decoloration of brick; (5) barium salts, especially barium carbonate, are economical since small quantities are sufficient. M.V.K.

Heat content of gases from 0 to 1900°C. G. B. TAYLOR. *Ind. Eng. Chem.*, **26** [4], 470 (1934). F.G.H.

Heat of formation of SiF_4, CF_4, and SiC. H. v. WARTENBERG AND R. SCHUTTE. *Z. anorg. allgem. Chem.*, **211** [3], 222–26 (1933).—The heats of formation of SiF_4 and of CF_4 were determined from the direct reaction of the elements, and the heat of formation of SiC, from the reaction of SiC with F. The following values were obtained: Si (crystalline) + $2F_2$ = SiF_4 + 360 ± 3; C (graphite) + $2F_2$ = CF_4 + 162 ± 2; and Si (crystalline) + C (graphite) = SiC + 31 ± 6. L.T.B.

Isothermal crystallization or change of certain masses with time. G. TAMMANN. *Z. anorg. allgem. Chem.*, **214** [4], 407–13 (1933).—A theoretical discussion and classification are given of types of crystallization or polymorphous change as the change proceeds from crystal or transformation nuclei. L.T.B.

Liquids of high refractive index. B. W. ANDERSON AND C. J. PAYNE. *Nature*, **133** [3350], 66–67 (1934).—Immersion media of indices above that of sulfur in methylene iodide (N_D <1.79) are listed for use in determining the refractive indices of crystals whose index exceeds 1.79. Tetra-iodo-ethylene, C_2I_4, dissolves in methylene iodide (22% at 15°C) and with sulfur in this liquid forms a clear, stable solution, N_D = 1.81, adapted for routine use with the refractometer. Phenyldi-iodoarsine, $C_6H_5AsI_2$, is a clear orange liquid, $D^{18°}$ = 2.56, with a high refractive index and dispersion as shown:

$\lambda(A)$	6708	6438	6141	5893	5535	5350	5106
$N^{18°}$	1.822	1.828	1.835	1.843	1.856	1.865	1.879

Phenyldi-iodoarsine has a blistering action on the skin and should be handled carefully. Selenium bromide, Se_2Br_2, has a higher index than that of any pure liquid so far discovered. Prepared by direct combination, N_{Li} is 1.96 ± 0.01 rising to 2.02 on exposure to atmosphere. Selenium bromide can be mixed with methylene iodide to give a series of liquids of high refractive indices. The use of transparent zinc blende (N_D = 2.37) is suggested for use in the construction of refractometers to read above 1.90. J.L.G.

Melting ranges of silicon dioxide–glass oxide systems and some conclusions. M. HOLLENWEGER AND H. RUMPELT. *Angew. Chem.*, **46** [42], 662–67 (1933).—Melting relations were determined in some systems of SiO_2–glass oxides. Systems consisting of 55 to 87.5% SiO_2 with 45 to 12.5% glass oxides are pure physical solutions of the glass-oxide molecules in quartz after melting. Systems of more than 87.5% SiO_2 and less than 12.5% glass oxides are solid solutions in which the foreign molecules are in the quartz lattice. These structures exist only in the melting range and somewhat below, since on cooling pure quartz separates. L.T.B.

Micro-acidometric method for the determination of nickel. J. V. DUBSKY AND E. HAUER. *Mikrochemie*, **12**, 321–26 (1933); *Analyst*, **58**, 305 (1933).—Ni is precipitated with dicyanidamidine, and the precipitate is dissolved in a known volume of standard HCl according to the equation, $Ni(C_2H_5NO)_2$ + 4HCl ⇆ $NiCl_2$ + $2(C_2H_6N_4O{\cdot}HCl)$, methyl red being used as indicator. H.H.S.

New science of rheology. E. C. BINGHAM. *Rev. Sci. Instruments*, **4** [9], 473–76 (1933).—A discussion is given of the new science of rheology, or science of flow, of its relation to clay, pitch, glue, paint viscose, etc., and of its

interrelationship with physics and chemistry as a science. A.K.

Note on gas analysis with modified Orsat apparatus. A. C. EGERTON. *Jour. Sci. Instruments*, **11** [1], 28 (1934).—Ordinary absorption bulbs are replaced by pipettes into which a fountain of liquid reagent sprays. A complete analysis for CO_2, O_2, and CO is possible in 10 min. Aniline was used in the burette instead of water because of its lower vapor pressure, its shallow well-defined meniscus, and its absence of drop formation on the glass due to grease. When hydrocarbons are present aniline should not be used. After using ammoniacal reagent, gases are passed into 40% H_2SO_4 solution to remove ammonia. Volumetric analysis of air for O_2 could be repeated to 0.1% accuracy. J.L.G.

Optics of inhomogeneous substances. M. HERZBERGER. *Z. Instrumentenk.*, **53** [10], 436–43 (1933); abstracted in *Physik. Ber.*, **15** [1], 54 (1934). M.H.

Pyrite-marcasite relation. M. J. BUERGER. *Amer. Mineral.*, **19** [2], 37–61 (1934).—Control of precipitation of pyrite and marcasite suggests that these two minerals are not a dimorphous pair but are chemically distinct compounds. A study of all available analyses indicates that pyrite is FeS_2, but marcasite is sulfur-low. Allen and Johnston's precision analyses bear out this conclusion. Marcasite, an isomorphous arsenic analogue (löllingite), is more iron-rich than $FeAs_2$. Its crystal structure is a function of chemical composition. The excess iron in marcasite and löllingite can be accommodated in the crystal structure in only one of three possibilities: interstitial solid solution, omission solid solution, or proxy solid solution. By comparing the unit cell densities with the experimentally determined densities of löllingite and marcasite, the excess iron is due to proxy solid solution. The chemical formula is

$$\text{Löllingite: } Fe\left|\begin{matrix}Fe\\As\end{matrix}\right|_2 \qquad \text{Marcasite: } Fe\left|\begin{matrix}Fe\\S\end{matrix}\right|_2$$

A.K.

Rule for the interpretation of melting-point diagrams. ROY F. NEWTON. *Science*, **79** [2049], 321–22 (1934).—N. suggests a useful rule in determining the number of phases present in a two-component system represented by any given region of the diagram. A horizontal line represents the conditions under which the coexistence of three phases is possible. Three regions of one phase touch the horizontal line at only one point each. Regions of two phases which touch the line are in extended contact with it. Illustrated. A.K.

Separation of potassium and sodium chlorides by means of aniline bitartrate. J. KUNZ. *Helv. Chim. Acta*, **16**, 259–61 (1933); abstracted in *Analyst*, **58**, 302–303 (1933). H.H.S.

Separation of various constituents of clay. P. URBAIN. *Compt. rend.*, **198** [10], 964–67 (1934).—A method of separating all constituents of a clay in twelve operations is described in detail. Four principal fractions are obtained: a completely washed crystalline fraction, a colloidal fraction rich in positive particles (metal hydroxides), a colloidal fraction rich in negative particles (silicates of hydrated alumina), and a saline solution; each group can be analyzed separately so that a complete analysis is obtained. M.H.

Significance of equilibrium diagrams. ANON. *Iron Age*, **133** [10], 25–25*B* (1934).—A rational understanding of equilibrium diagrams is given. Although commercial products are seldom in the equilibrium condition, only knowledge of the constitution in the completely stable condition permits intermediate points to be envisaged. The exposition is a unique supplement to the usual diagrammatic illustration of the theory of heterogeneous equilibrium. A.K.

Silicosis prevention: Determination of quartz-dust particles in the atmosphere. F. LÖWE. *Chem.-Ztg.*, **57**, 524 (1933); abstracted in *Analyst*, **58**, 571 (1933).—Quartz has the same refractive index as tetraline, and is therefore invisible in a field of that liquid, while other atmospheric particles are not. H.H.S.

Some optical and crystallographical properties of the alkali zinc uranyl acetates. HERBERT INSLEY AND FRANCIS W. GLAZE. *Bur. Stand. Jour. Research*, **12** [4], 471–74 (1934).—In studying the application of the Barber and Kolthoff method for the quantitative determination of sodium to the analysis of glass, a casual examination of the crystalline precipitate showed that the crystals, in general, were well formed and were characterized by twinning. Barber and Kolthoff stated that part of the potassium and most of the lithium are precipitated with the sodium salt when they are present. Because lithium can not be separated from sodium, but the potassium can be separated if proper precautions are taken, it was decided to determine the optical and crystal form of the zinc uranyl acetates of the three salts which are reported. Evidence obtained indicates that there is little prospect that separations of sodium and lithium by precipitation with zinc uranyl acetate can be made. R.A.H.

Spectroscopic analysis of minerals with the aid of the acetylene-air flame. A. K. RUSANOV. *Z. anorg. allgem. Chem.*, **214** [1], 77–80 (1933).—A convenient means for the study of solid substances is described. The spectra obtained by this means are sharper and have more lines than the usual spectra. A quantitative estimate of the elements in minerals is possible. By this method the solid powder is introduced directly into the flame. See also *Ceram. Abs.*, **12** [12], 433 (1933). L.T.B.

Stannous oxide and the system SnO-SiO_2. B. KEYSSELITZ AND E. J. KOHLMEYER. *Metall & Erz*, **30** [10], 185–90 (1933).—A study of the behavior of stannous oxide (and oxalate) on heating in an atmosphere of nitrogen is given. At 490°C it undergoes an irreversible change of modification; it decomposes at 540° and melts at 1000°. In silicate mixtures it goes into solution below 540°C so that there is no decomposition in such melts. There is no appreciable vaporization of stannous oxide up to 1000°C and in the silicate mixtures there is no appreciable vaporization up to 1250°C. The melting temperatures of various mixtures in the system SnO-SiO_2 are reported. L.T.B.

Studies on glass. VIII. The coefficient of thermal expansion of boron trioxide. MONROE E. SPAGHT AND GEORGE S. PARKS. *Jour. Phys. Chem.*, **38** [1], 103–11 (1934).—By use of a small dilatometer with mercury as the dilatometric fluid the coefficients of thermal ex-

pansion of two samples of boron trioxide have been measured between 100 and 325°C, with a probable experimental error of less than 5%. The coefficient for the viscous liquid is more than ten times that for the glassy state. The character of the expansion coefficient-temperature curves below 260°C depends upon the extent of the annealing during the initial formation of the glass. A.K.

The system cadmium sulfate–sulfuric acid–water. R. ARDITTI. *Compt. rend.*, **197** [21], 1209–11 (1933).—Three solid phases exist: $SO_4Cd \cdot {}^6/_5H_2O$, $SO_4Cd \cdot H_2O$, and $SO_4Cd \cdot H_2SO_4$. The physical constants were determined for the whole system. M.H.

Transformations of kaolin on calcination. R. DUBRISAY AND H. LA FUMA. *Céramique*, **36**, 290–93 (1933).—Kaolin on being heated to 500°C undergoes an endothermic transformation resulting in dehydration. A second exothermic transformation takes place at 900°C and results in the formation of sillimanite. These transformations were determined by noting the behavior of suspensions and the character of their deposits in alkaline solutions of varying concentrations. M.H.B.

Volumetric determination of tin; use of potassium iodate. J. B. RAMSEY AND J. G. BLANN. *Jour. Amer. Chem. Soc.*, **56** [4], 815–18 (1934). F.G.H.

BOOKS

Aids to Qualitative Inorganic Analysis. R. G. AUSTIN. William Wood and Co., Baltimore, Md., 1934. 204 pp. Price $1.50. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [4], 1004 (1934). F.G.H.

Easily Interpolated Trigonometric Tables with Non-interpolating Logs, Cologs, and Antilogs. F. W. JOHNSON. Simplified Series Publishing Co., San Francisco, Calif., 1934. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [3], 752 (1934). F.G.H.

Introductory Colloid Chemistry. H. N. HOLMES. John Wiley and Sons, Inc., New York, 1934. 198 pp. Price $2.50. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [5], 1256 (1934). F.G.H.

PATENTS

Defoamed product. JACOB WOLFSON (National Oil Products Co.). U. S. 1,957,514, May 8, 1934. A defoamed product consists of a mixture of glue, a dispersed aluminum stearate, and sulfonated tallow.

Means and method of defoaming. JACOB WOLFSON (National Oil Products Co.). U. S. 1,957,513, May 8, 1934. (1) In a process for defoaming foamable products, the step comprises adding a dispersed water insoluble metallic soap to the product to be defoamed. (2) A new defoaming agent is a mixture of a water-insoluble metallic soap, a wax solvent for the metallic soap, and a sulfonated organic dispersing agent.

Method of precipitating titanium compounds. W. J. CAUWENBERG (Titanium Pigment Co., Inc.). U. S. 1,957,528, May 8, 1934.

Manufacture of titanium compounds. TITANIUM PIGMENT CO., INC. Brit. 408,215, April 18, 1934.

General

Canadian Ceramic Society holds successful meeting. ANON. *Clay Prod. News*, **7** [3], 1–3 (1934). A.J.M.

Ceramic ware to be made at the 1934 Century of Progress Exposition. ANON. *Bull. Amer. Ceram. Soc.*, **13** [5], 144 (1934).

Experimental silicosis: quartz, sericite, and irritating gases. W. D. ROBSON, D. A. IRWIN, AND E. J. KING. Presented at meeting of Toronto Biochemical Society, March, 1934; abstracted in *Can. Chem. Met.*, **18** [4], 75 (1934).—Exposure of rabbits to dilute gases (NO_2 and SO_3) produced degenerative lesions in the lungs and predisposed to pneumonitis. Exposure of rabbits to dilute irritating gases combined with silica dust gave rise in periods of 13 weeks or more to an acute pulmonary silicosis characterized by typical siliceous fibrotic nodules in the alveoli, in the lymphatic aggregations, and in the lymphatic glands. Exposure of rabbits to dilute irritating gases combined with sericite dust did not produce fibrotic change in the lungs in an exposure of 40 weeks. E.J.V.

Histological diagnosis of silicosis. D. A. IRWIN. Presented at meeting of Toronto Biochemical Society, March, 1934; abstracted in *Can. Chem. Met.*, **18** [4], 75 (1934).—In micro-incineration lies the best method of relating histological structure to siliceous material present in any tissue. Micro-incineration should be included in routine microscopic examination of any lung where siliceous fibrosis is suspected, not with any dogmatic predictions but as a surer diagnosis and a better understanding of the pathogenesis of siliceous fibrosis. E.J.V.

Newcomb pottery active in New Orleans. PAUL E. COX. *Bull. Amer. Ceram. Soc.*, **13** [5], 140–42 (1934).

Silica dust. W. R. FRANKS. Presented at meeting of Toronto Biochemical Society, March, 1934; abstracted in *Can. Chem. Met.*, **18** [4], 75 (1934).—Silicosis is an insidious poisoning caused by silica taken in from the dusty atmosphere. A photometric method of estimating the dust concentration was described. In this the value obtained is proportional to the surface of the dust, on which factor also depends the liberation of the toxic substance. Free quartz also gives higher values than other silicates studied. The experimental application of electrical precipitation for dust removal underground resulted in the dust in a mine drift formed by blasting being reduced from 15,000 to 200 particles per cc. within a half hour. E.J.V.

Silicosis: its causation. BENJAMIN F. TILLSON. *Eng. Mining Jour.*, **135** [3], 121–24 (1934).—The mechanical and physiological aspects are considered. Silica dust found in lungs varies from $^1/_2$ to 10 microns in maximum dimension. The silica dissolved by alkline body fluids has been proved responsible for the abnormal conditions of cell structure of the lungs. Fatal amounts are considered from data from post mortem investigations. Spraying dust with water does no good since particles may be car-

ried on tiny droplets of water inhaled. The respiratory tract is considered as a ventilating system with its numerous dust traps. The structure of the lungs is considered in detail and nature's defences against silicosis are described. Possible preventive measures are listed. See also *Ceram. Abs.*, **13** [6], 165 (1934). J.L.G.

Silicosis and the metabolism of silica. E. J. KING AND M. DOLAN. Presented at meeting of Toronto Biochemical Society, March, 1934; abstracted in *Can. Chem. Met.*, **18** [4], 75 (1934).—Silica in small amounts appears to be a natural constituent of all animal tissue. Silica, which reaches the blood stream either by absorption from the gut or solution in the lung, is rapidly excreted in the urine. Soluble silica injected into the blood is quickly eliminated in the urine. There appears to be a low kidney threshold for silica. The urinary excretion of silica is at a higher level in persons exposed to silica dust than in normal persons. Attempts to influence the absorption of silica from the lungs by administration of alkali gave inconclusive results. Elimination of silica by way of the sputum from patients having deposits of silica in their lungs appears to be higher than in those having no history of exposure to dust. Only small amounts of silica are present in the blood. No significant differences were found between its level in the blood of normal and silicotic persons. E.J.V.

BOOK REVIEWS

Abstracts of Papers Presented at the First International Congress on Glass and Ceramics (Riassunti Internazionale del Vetro e della Ceramica). Milan, Italy, September 16–25, 1933. 118 pp. This excellently published book is divided in two parts: (1) abstracts of 32 papers devoted to ceramics, (2) abstracts of 40 papers on glass. Every abstract is printed in one of the four languages: Italian, English, German, and French. Beside every abstract outlined in one of the three first languages is a French translation. The numerous important papers on glass and ceramics presented at the Congress by the leading authorities of the great countries of the world emphasize the outstanding rôle of the First International Congress on Glass and Ceramics as a foundation in international coöperative work in this field for the exchange of opinions and promotion of knowledge of glass and ceramics, tending to bring all nations to a higher standard of culture.

S.I.PERKAL

Memorandum Book for Glass, Ceramics, and Enameling, 1934. JACQUES WOLF. In French only. Ed. Universelle, Bruxelles. 384 pp. 20 F. belge. This book gives a comprehensive review of (1) the nature of glass, (2) its raw materials, (3) manufacture, (4) mechanical processes, and (5) chemical processes. The part devoted to ceramics gives (*a*) their classification, (*b*) raw materials, (*c*) examination of raw materials, and (*d*) elementary notion of principal ceramic materials: refractory products and their classification, manufacture, properties, and testing methods. The part dealing with enamels discusses (1) metals, cast iron, and sheet iron, (2) precious metals, (3) working of the surface, (4) raw materials, (5) compositions and preparation of enamels, and (6) coating and firing. The third part of the book gives a list of Belgian and French glass manufacturers and a list of supply firms. The fourth part gives various physical, chemical, and technical data. Indexes of literature are given.

M.V.KONDOIDY

Microscopic determination of nonopaque minerals. ANON. *U. S. Geol. Surv. Bull.*, No. 848, 254 pp. Supt. of Documents, Washington, D. C. 20¢. This new edition of *U. S. Geol. Surv. Bull.*, No. 679, issued in 1921, has been completely rewritten. Five hundred new entries and 100 changes in old entries bring the tables up to date; 250 new mineral species are included, and tables have been added in which the data on the important mineral groups have been assembled. This edition entirely supersedes the earlier one and will be a necessary reference work for all who identify minerals.

Most Important Stages in Development of Chemistry for the Last One Hundred and Fifty Years. B. N. MENSHUTKIN. Pub. House of the Academy of Sci., Leningrad, 1933. 120 pp. Price 1.25 R. It is universally considered that silicate chemistry is the foundation of the silicate industry, and it is also evident that general chemistry is the basis of the silicate chemistry. This dependence existing between the two branches of chemistry makes a book, like the review, dealing with general development of chemistry interesting for every silicate technologist both from cultural and industrial standpoints. S.I.PERKAL